JUN 24 1919
UNIV. OF MICH.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVII.—No. 2786.] *LONDON: FRIDAY, MAY 23, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE 9d. BY INLAND POST ... 11d.

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JOHN ANSTEE,
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J. ANTHONY PARKER, U 954
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Tenders will be received until 10 a.m. on 31st May, 1919.

The Port Authority do not bind themselves to accept the highest or any Tender.

F. AYLIFFE,
Secretary.

Port of London Authority,
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By order,
W. B. REYNOLDS
(for Managing Director).

Finsbury Pavement House, E.C. 2.
19th May, 1919. W 8

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The lowest or any Tender not necessarily accepted. W 55

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R. F. DUNNELL, Secretary, York, 20th May, 1919. W 37

G. R.

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U 616

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University College,
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MODEL EXPERIMENTS IN AERONAUTICS.

ALTHOUGH the war has been the main incentive to the very remarkable development in aviation during the last few years, it has, at the same time, had the effect, to a very large extent, of hiding from view the means by which this progress has been made. Few persons outside the air services, and the aircraft industry, are aware of the difficult and dangerous experiments that have been carried out, notably by the staff of the Royal Aircraft Factory, in order to provide data necessary for the improvement of design. In aircraft construction, where weight is of such extreme importance, it is obviously necessary to use the materials available to the best possible advantage, and, in order to do this, the designer must know as accurately as possible the forces which the materials have to resist. Fortunately, much of the necessary information can be obtained by means which do not involve risk to life, and are, moreover, much less costly than are experiments on full-size machines. We are referring, of course, to experiments on models in a wind tunnel. The vast mass of data accumulated by this means during the course of the war has undoubtedly been of great service to designers, and has contributed in no small measure to the rapid progress made. In addition to the two important advantages previously mentioned, model experiments enable data to be obtained quickly under conditions that can be readily controlled, and also, by rendering possible the omission of parts essential in actual flight, they can provide information relating to the effects of such parts that could not be obtained by other means. The actual forces and moments on the model can now be measured with a very high degree of accuracy, so that, if these results could be applied with certainty to the full-size machine, all the data necessary for the design of a machine, and for the prediction of its performance, could be obtained from model experiments. This, however, is the difficulty; the application of model results to full-size aeroplanes is by no means simple, and, though the great quantity of data, of an empirical nature, now available enables this to be done in most cases with sufficient accuracy for practical purposes, considerable experience and discrimination are required. This need for judgment, and the fact that occasionally considerable discrepancies are found between model results and full-size achievements, shows the need for further study of the physical laws which connect the size and speed of a body with the forces brought into play by its motion in a fluid medium.

The properties of air, the medium with which we are concerned in aeronautics, that may affect the motion of a body in it are its density, viscosity and compressibility. Of these, the latter can be neglected in aeronautical problems, since it can be amply demonstrated, both experimentally and mathematically, that the effects of compressibility are not serious until speeds approaching that of sound waves in air are reached. At the highest flight speeds yet attained the resistance of a body is affected by much less than 1 per cent. by the compression of the air. It is therefore justifiable to assume that we are dealing with an incompressible viscous medium. In such a medium viscous forces arise from the fact that contiguous layers of fluid move with different velocities, as can be seen in Fig. 1. This represents the flow of water past a flat plate, the dashes indicating by their lengths the movement of particles of water in equal intervals of time. Near the plate it will be noticed that the dashes are very much shorter than those some distance away, which, of course, shows that the velocity of the fluid diminishes as the surface of the solid body is approached. At the surface of the body the relative velocity of the fluid and body is zero, and, although definite experimental evidence of this is difficult to obtain in the case of air, there is, as far as we are aware, no data available to disprove the statement. This is equivalent to the statement that there is a continuous distribution in velocity from the interior of the body to the interior of the fluid.

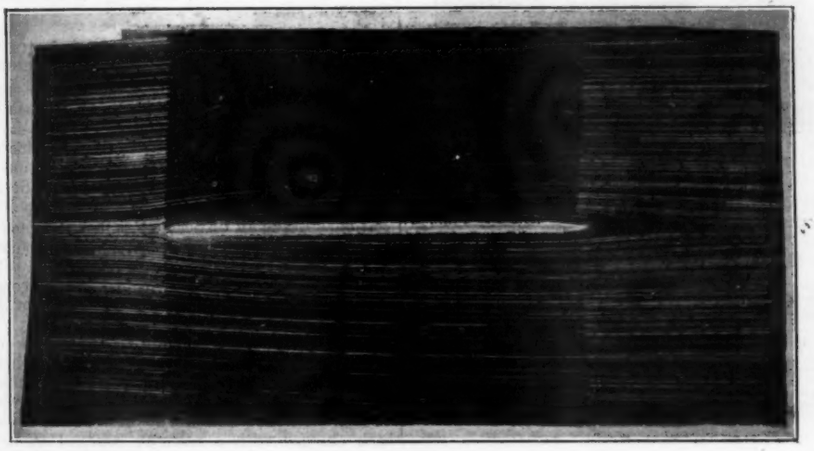


FIG. 1.

With these assumptions we can now determine the conditions which must be satisfied to obtain exact correspondence between model experiments and full-size results, and, in doing so, we are making use of a very valuable paper recently read before the Royal Aeronautical Society by Dr. H. Levy, of the National Physical Laboratory. Suppose a body of given shape, and size determined by one of its dimensions l, to be moving with uniform velocity V in a fluid of density ρ and kinematic viscosity ν of infinite extent. Then v, the velocity of a fluid element at any point, can depend only on V, ρ, ν, l and t, where t is the time at which the motion is considered, and, of course, on the shape of the body. We may therefore write

$$v = \mathrm{F}(\mathrm{V}, \rho, \nu, l, t)$$

and applying the principle of homogeneity of dimensions, it can be shown that each term in the expansion of the function must be of the form $\mathrm{A}\,\mathrm{V}\left(\frac{\mathrm{V}l}{\nu}\right)^m\left(\frac{\mathrm{V}t}{l}\right)^n$ where A, m and n depend only on the shape of the body. Hence:

$$v = \mathrm{V}\,\Sigma\,\mathrm{A}\left(\frac{\mathrm{V}l}{\nu}\right)^m\left(\frac{\mathrm{V}t}{l}\right)^n$$

$$= \mathrm{V}f\left(\frac{\mathrm{V}l}{\nu}, \frac{\mathrm{V}t}{l}\right)$$

where the form of the function depends absolutely on the shape of the body. In the same manner it may be shown that θ, the direction of flow at the point under consideration, is such that $\theta = g\left(\frac{\mathrm{V}l}{\nu}, \frac{\mathrm{V}t}{l}\right)$. The expressions thus obtained are very general statements regarding the nature of fluid motion, and they may be used to establish the conditions necessary for the application of model experiments to full-size machines.

If, now, we have two bodies of similar form, but of different dimensions, given by l_1 and l_2, moving in different fluids, the viscosities of which are ν_1 and ν_2, at steady speeds denoted by V_1 and V_2, we shall have two corresponding speeds given by $\frac{\mathrm{V}_1 l_1}{\nu_1} = \frac{\mathrm{V}_2 l_2}{\nu_2}$ and two corresponding times given by $\frac{\mathrm{V}_1 t_1}{l_1} = \frac{\mathrm{V}_2 t_2}{l_2}$ for which $\theta_1 = \theta_2$. That is to say, at corresponding times, the direction of flow at all geometrically corresponding points will be indentical, the two systems will, in fact, be dynamically similar. By suitably choosing the velocity we can thus study the flow of air round a body by experiments similar to that illustrated in Fig. 1, on the flow of water round a body of similar form, the two problems being physically identical if the value of $\frac{\mathrm{V}l}{\nu}$ is the same in each case. Moreover, it follows that if we are dealing with one medium only, air for example, the two systems of stream lines will be identical at corresponding times if we make $\mathrm{V}_1 l_1 = \mathrm{V}_2 l_2$.

The general expression for the resistance of a body we find, by again applying the principle of homogeneity of dimensions, to be

$$\mathrm{R} = \rho\,\mathrm{V}^2 l^2\,\mathrm{F}\left(\frac{\mathrm{V}l}{\nu}, \frac{\mathrm{V}t}{l}\right),$$

the form of the function being determined entirely by the form of the body. It therefore follows that two bodies, similar in form but differing in dimensions, moving in the same medium, will have exactly the same resistance at corresponding times provided that the velocities are inversely proportional to the linear dimensions. This, then, is the condition necessary for the accurate application of the results obtained in wind-tunnel tests on models to full-size aeroplanes, but, unfortunately, a little consideration will show that the conditions are, in most cases, unattainable in practice. The scale of a complete model aeroplane is usually limited by the dimensions of the wind tunnel to about one-fifteenth full size, so that, if the machine is intended to fly at 100 m.p.h., the air speed required for the model test would be 1,500 m.p.h. At this air speed, which is obviously quite impracticable, the forces on the model would be the same as those on the full-size machine, and it would not be possible to construct a model strong enough to resist them. Moreover, our first assumption that the effects of compression were negligible would be nullified. In the cases of small component parts, such as wires, fittings, struts, &c., for which models larger than full size can be employed, the objection disappears. If, for instance, it be required to find the resistance of a certain fitting at 150 m.p.h., the results obtained by testing in a wind tunnel a model fitting three times the full size at 50 m.p.h. may be used without correction. The only method available for dealing with cases in which the model must be much smaller than the full-size machine is to test the model at increasing values of $\mathrm{V}l$ until the highest possible value is reached. At the higher values of $\mathrm{V}l$ the resistance coefficient will probably tend to become more or less constant, because, in general, R varies as v^2, so that by plotting the coefficient on a $\mathrm{V}l$ base, and extrapolating on the curve, an approximately correct value of the coefficient for the full-size body may be obtained. It may here be noted that, although the term $\frac{\mathrm{V}t}{l}$ appears in the general expression for resistance, the actual variations of the latter with time are so rapid that the forces measured in wind-tunnel experiments, at uniform speeds, appear to be quite constant.

So far we have considered only cases in which the body is in steady motion. These, however, are not the only aeronautical problems requiring attention. In studying the problem of stability of aircraft it is necessary to take account of the effects of acceleration—a matter of considerable importance in connection with airships; the extra resistance due to acceleration is, in fact, directly involved in the problem of virtual mass. With accelerated motion it can be shown by reasoning similar to that outlined above that θ, the direction of motion of the fluid at any point

fixed geometrically with reference to the body, will be such that $\theta = F\left(\frac{v\,l}{\nu}, \frac{a\,l}{v^2}\right)$, where v and a are the instantaneous values of the velocity and acceleration of the body, respectively. As in the previous cases, the form of the function depends only on the shape of the body, and thus it again follows that if $\frac{v\,l}{\nu}$ and $\frac{a\,l}{v^2}$ are kept constant for the model and the full-size body, the systems will possess dynamical similarity, and be strictly comparable. Under these conditions the expression for the resistance will take the form $R = \rho v^2 l^2 f\left(\frac{v\,l}{\nu}, \frac{a\,l}{v^2}\right)$, and thus it will be seen that for accelerated motion the resistance depends upon the quantity $\frac{a\,l}{v^2}$ as well as on $\frac{v\,l}{\nu}$. Fortunately, however, the practical difficulties met with on account of the large values of $v\,l$ required for accurate model tests

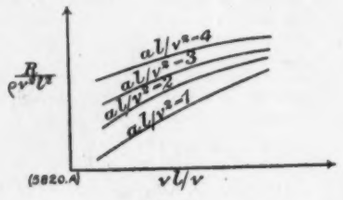


FIG. 2.

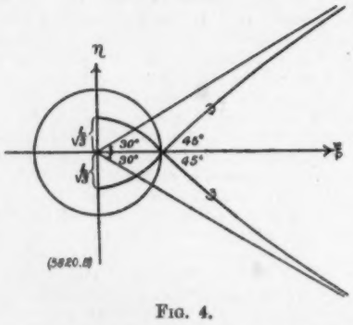


FIG. 4.

do not arise in connection with the acceleration term. An experimental method, devised, we believe, by Messrs. Levy and Cowley, has been tried with very encouraging results at the National Physical Laboratory. By allowing a model, suitably weighted, to fall freely in water until its terminal velocity is reached, the whole range of values of $\frac{a\,l}{v^2}$ from infinity to zero, will be passed through, since at the commencement of the fall v will be zero and a will have a finite value, while, when the terminal velocity is reached, a will be zero and v will be finite. From the results of such experiments a diagram, such as Fig. 2, which shows the value of the resistance coefficient plotted over a $\frac{v\,l}{\nu}$ base for various values of $\frac{a\,l}{v^2}$ may be prepared.

From the foregoing matter it will be seen that, although for every full-size experiment there exists a corresponding model test, the conditions necessary for accuracy in the latter cannot, in general, be realised. To deal confidently with these cases it is evidently desirable to make a more accurate study of the laws of resistance from the theoretical standpoint, and this involves an investigation of the fluid flow past a body under any given conditions, since the resistance depends upon the rate at which energy is impressed on and dissipated by the fluid. The problem, however, is one of extreme difficulty. The equations of motion for a viscous incompressible fluid are exceedingly complicated, and attempts to solve them by standard methods have, so far, met with little or no success. It is, of course, possible to obtain more manageable equations by neglecting the effects of viscosity, but the results obtained with such an ideal fluid have little bearing on the practical problems of aeronautics. Evidently what is required to throw full light on many problems which are now obscure is a complete solution of the equations of motion for a viscous fluid, but, as that seems to be beyond our reach at present, we are forced to consider any means of getting round the difficulties, which do not involve unjustifiable assumptions. Such a means is put forward by Dr. Levy in the paper above referred to, and, although we cannot spare the space necessary to develop it fully here, the method seems to be of quite sufficient interest and importance to justify our calling attention to it.

To put the matter as briefly as possible, it appears that, in all cases of fluid motion that occur in practical aeronautics, special centres of rotation, or eddies, develop in the fluid, and the nature of the flow seems to be largely determined by the position and strength of these eddies. They are well shown in Fig. 3, which is reproduced from a photograph of the flow of water past a cylinder. Such eddies cannot originate in a fluid devoid of viscosity, and

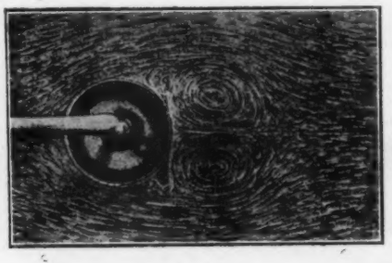
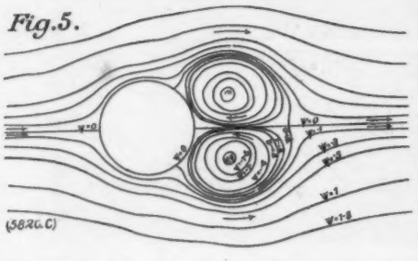


FIG. 3.

Fig.5.



this accounts for the serious discrepancy between calculations made for a perfect fluid and results obtained with actual fluids. By the aid of reasoning similar to that indicated above, it is found that the total vorticity, K, within a small circle surrounding one of the centres of rotation is such that $K = \nu f\left(\frac{v\,l}{\nu}, \frac{v\,t}{l}\right)$, the form of the function again depending only on the shape of the body. If, then, $\frac{v\,l}{\nu}$ be kept constant in a series of experiments, the strength of the eddies set up will be proportional to the viscosity. From this Dr. Levy suggests that, if we imagine vortices of given strength to be situated in given positions in a fluid devoid of viscosity, the motion of this ideal fluid will be identical with that of an actual fluid possessing viscosity, and that all the conditions necessary for dynamical similarity will be satisfied at corresponding values of $\frac{v\,l}{K}$ instead of $\frac{v\,l}{\nu}$. In this way the problem is made amenable to mathematical treatment. By an application of this method of reasoning he then shows that, for normal flow along a channel, a critical state occurs for $\frac{v\,l}{K} = \frac{1}{2}$ in conformity with the results obtained by O. Reynolds in his experiments on the flow of water in pipes. As a further example of the application of the method to a practical problem in aeronautics, Dr. Levy proceeds to investigate the flow round a cylinder, first to ascertain whether a position of equilibrium can be found behind the cylinder for the two eddies shown in Fig. 3, and then, assuming the eddies to occupy that position, to see how the resulting system of stream lines agrees with that shown in the photograph. The results are illustrated in Figs. 4 and 5. In Fig. 4 two curves are drawn on which it was calculated that the eddies must lie, and direct measurements show that the actual eddies of Fig. 3 do, in fact, lie very accurately on the curves. The stream lines, shown in Fig. 5, also calculated on the above-mentioned assumptions, are also in reasonably good agreement with those of the actual photograph, Fig. 3.

Although this good agreement between theor and practice is distinctly encouraging, one must not expect too much from it. It must be remembered that the vorticity has been assumed to be concentrated at two points of equilibrium, whereas actually it would spread continuously throughout the whole of the fluid, though falling off rapidly from the points of concentration. This would give rise to some discrepancy. On the whole, however, we think that theoretical and experimental investigations continued along the lines very briefly indicated above, may throw a useful light on some of the problems which at present render the transition from model experiments to full-scale work uncertain and obscure.

THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 631.)

THE first paper taken at the meeting of the morning of Friday, the 9th inst., was one by Professor Henry M. Howe, Honorary Vice-President, New York, on

THE WORK OF THE ENGINEERING DIVISION OF THE UNITED STATES NATIONAL RESEARCH COUNCIL.

Professor Howe read his paper in full, and stated that the American National Research Council was an Institution not for executing, but for stimulating, scientific and technical research, and to this end it aimed to become an affiliation of the scientific and research interests of the United States. It derived its authoritativeness from being a committee of the National Academy of Sciences, a body erected by Government charter, and in general corresponding to the British Royal Society. It was self-directing and free from bureaucratic control. The council was composed of thirteen divisions, each devoting itself to a special field.

He confined himself chiefly to the Engineering Division, because it aimed to cover all branches of metallurgy. Research was stimulated chiefly through the creation of active committees, of which the division in question had now about twenty, each charged with a research believed to be of engineering importance. The members of each committee were all intended to be active in executing its work, in connection with their own regular work in the laboratory or other research—educational or industrial institutions—in which they were engaged. Thus there were brought to bear on each problem the men fittest for studying it, and the resources of a number, sometimes a very large number, of the best equipped laboratories in America. They did not intend to create laboratories of their own, believing that their chosen task of stimulating the workers in other laboratories, of helping to lessen needless duplication, and of acting as a sort of clearing house was best isolated from the equipping and maintaining of laboratories of their own.

The first problem taken up by the division was the fatigue of metals, under the chairmanship of Professor Herbert F. Moore, of the University of Illinois, with six other members representing the United States Bureau of Standards, two institutions of learning and four industrial research departments. The thorough study of fatigues, as influenced by the microstructure, the composition and condition of the metal, and the ranges of frequency of repetition, required such very extensive and prolonged tests that the world seemed to have baulked at it. It needed an attack on a national, if not, indeed, on an international scale.

The Research Council had not the funds to finance twenty such active investigation committees for each of the thirteen divisions. In this and other cases they hoped to get the money needed from the presumptive beneficiaries of the research.

Other committees were dealing with alloy steels; with the improvement of metal by treatment at a blue heat; and with the heat treatment of carbon steel.

In order to illustrate our lack of knowledge in the

matter of alloy steels, Professor Howe stated that an American gun maker was much troubled with flakes ("snow flakes") in nickel steel. By halving the nickel content, the flakes were greatly reduced, without preventing the product from passing the reception lists; by omitting all nickel, the flakes disappeared almost totally and the product continued to pass the reception tests. Here, therefore, a costly addition of 4 per cent. of nickel was a positive damage, as far as concerned the reception tests.

The council expected to be also useful in improving the general environment of research, for instance, by propaganda aimed to cause the American institutions of learning to favour research by their own staff far more than at present, and impressing on the various industries the great benefits which the more progressive establishments are now gaining by their own resources.

Professor Howe added that an objection had been raised in some quarters to the effect that all the work of the council might repress individual activity. He thought, on the contrary, that the experience in the past in regard to committees wisely directed showed that these were very far from repressing individual activity. The Astronomical Society was a case in point; it did not discourage, but encouraged members and lifted them to a higher plane. The council, also, tended to the benefit of the community at large, and this after all was the end to be borne in mind, not so much the benefit of the individual.

Dr. Rosenhain, who opened the discussion, said he had listened to Professor Howe's paper with much interest, the subject dealt with being one of great importance. The organisation of research was very much in arrear. Professor Howe's concluding remarks were perhaps the most interesting. The revitalisation of research was very important, but he (the speaker) would like one point to be given careful consideration to, and questioned whether if an organisation for research tended to repress individuality it would not be a loss, on the ground that it was not the individual but the community that counted. Individual research work was to be encouraged; there was room for a large amount of routine work and pioneer work, and men capable of doing that needed stimulus. The community benefited by their individual activity. A large quantity of committee work had been carried out during the war, and that committee work did not repress individuality; on the contrary, it had a stimulating effect. Human rivalry came in and had its effect. The question dealt with was a large one and it could only be undertaken by large organisations; probably the organisations mentioned in the paper were the best for the purpose in view. He assured Professor Howe that we in this country would only be too pleased to apply the work carried out in the United States and that, on our part, we should render the scheme every possible help.

Professor Turner thought the Institute was greatly indebted to Professor Howe for having brought forward such an important subject. The organisation of research in the United States had already proceeded further than in this country, but the Department of Research in the United Kingdom had formed a number of committees on lines which were not far different from those outlined by Professor Howe. It was a wise course followed in America by which the central organisation was not intended to conduct research but to arrange for others to do so, to stimulate them and to provide the means. They should draw in the net the large laboratories, together with engineers to assist. When Professor Howe's paper is in print and in the hands of the members, the latter would carefully examine the scheme. Much benefit had already been derived from the research work carried out in the United States, but it was important that research should be still further encouraged and our knowledge increased. Professor Howe's scheme showed a wide and wise outlook on the subject, and was likely to lead to many important results.

Dr. Cottrell said he had been associated on the Government side with Professor Howe in the organisation outlined in the paper. The organisation formed a useful connecting link between the permanent Government bodies and the Academic bodies throughout the country; there was always a need for great co-ordination between the two. The organisation devoted itself entirely to its programme, it did a large amount of good work and took a stand that a private individual was unable to take. It had great initiative. In France, the same problems had to be faced. He (the speaker) here referred to the inter-Allied conference on chemistry which had been held in Paris about one month ago, very largely owing to the efforts of Professor Louis and Mr. P. Kestner, the President of the French Chemical Society, a conference at which the academic interest shown was very marked. The resolutions passed at the conference pointed to a development of international co-operation; to the association of various organisations parallel to the national councils of the United States, for the forming of a larger, international body with a view to further international co-operation. A Bill had been put forward in France for converting the French Munitions Department into a Peace Line Agency and coupling this up with academic and scientific bodies to form an association somewhat similar to the British Royal Society. The outlook for progress was thus very gratifying.

Professor Louis strongly emphasised the international side of the question, adding that work hitherto had been carried out too much in watertight compartments, as was evidenced to some extent by Professor Howe's paper. There was strong evidence that resources should be combined. He, personally, had never made of research a fetish with a capital R. The man capable of doing original research work was not born every day; the world did not get every day a Bessemer or a Crookes. The bodies such as those which had been formed in the United States and in other countries would render real service in picking out the men who could carry out real research work. It was right that such men, in whatever country they were born should be recognised not only as national, but also as international assets. International co-operation could also get through a large amount of spade work to clear the ground. Thus the committees referred to by Professor Howe would obtain from the American steel works a number of ingots, and these would be analysed and examined; a British committee under Dr. Stead was doing the same in this country, and the very first thing to be done on both sides was to exchange specimens. The same with France, Italy and other countries. The result would be that when we all were talking of steel we were using the same language. A national standard for steel was aimed at, but a step further should be taken and an international standard arrived at; international co-operation should be the object in view, every country coming in.

Professor Howe, in the course of his reply, stated that he agreed to some extent with Dr. Rosenhain; there was a shade of difference in the stimulating effect referred to. It was not the first class, but the second class man who required stimulating. The organisation referred to in the paper would remove from the first class man a great deal of detail work; the man of first ability, for example, would not be required to carry on tensile tests, but to have charge of directing all the work. He was very glad Dr. Cottrell and Professor Louis had emphasised the international side of the schemes. He (Professor Howe) had indicated what they were doing in the United States from the national point of view, and when the schemes referred to were internationalised they would have a very great international value. He expressed the hope that means would be taken for the exchange of steel specimens with friends on this side of the Atlantic.

On the motion of the chairman, Professor Howe was cordially thanked for his communication.

Modern Steel Metallurgy.

The second paper taken at Friday morning's meeting was the one on "Modern Metallurgy, Calculation of Comparison of Processes," by Mr. C. H. F. Bagley, who read it in abstracts.

The author said that his object in writing the paper was to present a simple and reliable method of calculating the consumption of materials and the technical results in the manufacture of steel from any kind of pig-iron by any standard process, so as to arrive at their relative advantages. The paper dealt with the slag formation, character and analyses, the elimination of the sulphur in the basic process, the working of the Bessemer acid and basic processes, and of the various open-hearth and Duplex processes, &c.

The discussion was opened by Mr. B. Talbot, who noticed that Mr. Bagley had expressed the hope that this contribution of his would be of general use; he (the speaker) congratulated him on having put forward a most excellent paper and one that would be of specific use to all open-hearth steel manufacturers in this country. It contained several very interesting balance sheets indicating what might be hoped for as output on the basis of the theoretical calculations, and the author was very near the actual shop results. An interesting comparison was that made between the different processes in regard to their yield, and when one came to the Duplex processes and saw their yield of 91 per cent. and 92 per cent., as against that of 105 of the direct Talbot process, the difference was really enormous, and in the face of such figures one could not understand the Duplex practice being extensively followed in the United States. The Talbot process, however, was also largely used in the United States. The author had referred to the tilting furnace; he (the speaker) did not see why makers were so nervous of the tilting furnace; it would be the furnace of the future and its size was still capable of great expansion. He could not follow the author in his statement to the effect that he (the author) had a system for recovering slag from fixed furnaces by blowing it off, whereby all the advantages of the tilting furnace were secured without its expense and upkeep.

Mr. F. W. Harbord also congratulated the author, adding that it was most important to get out balances in every operation, so that the man in actual charge of the operation should have a method of arriving at what he was doing, a means showing him what he ought to obtain and enabling him to make a comparison with what he was actually getting, without waiting for the data from the office. The man in charge of an open-hearth furnace on viewing the analysis of his slag showing the oxide of iron and lime, saw exactly what was aimed at and was stimulated to work economically and efficiently. He (the speaker) emphasised the great advantage of making basic pig-iron in the blast furnace, as this facilitated the work all through; it gave a highly phosphorous slag with a lower consumption of lime and made all the difference between the working paying or not.

Mr. T. Twynam said the 28 per cent. of acids in his slags seemed to be a very good figure; the question of the slags was a very important one all round and the possibility of making a slag higher in phosphoric acid than 22 per cent. put a new complexion on the basic process.

Professor Turner was glad to see the author pay so much attention to the quality and quantity of the slag. He (the speaker) had pointed out years ago how important was the slag in the purifying process; the slag was the smelters' friend if it was of the right composition and of the right fluidity. The testing of the slag, also, was of the greatest importance. In regard to the oxide of iron present in the slag, he had always viewed this, in the Siemens process, to be present as magnetic oxide, as, he thought, could be evidenced by the microscope. The point had been much argued; magnetic oxide gave the greater fluidity. The proper composition of the slag had, besides, a great effect on its market value and a percentage of, say 20 of phosphoric acid gave, it a greater value than a lower percentage.

Dr. Stead, who closed the discussion, said the paper would be of great value to students also, who should check the calculations and bear them in their minds. He wished to mention one point, in connection with the desulphurisation of iron by fluorspar, and the name of the originator of that process, Mr. Saniter, should, he thought, be referred to.

The author stated he would reply to the discussion by correspondence, and received the thanks of the meeting for his contribution.

Macro-Etching and Macro-Printing.

The next paper taken was one on "Macro-

Etching and Macro-Printing," by Mr. J. C. W. Humfrey.

In this, Mr. Humfrey pointed out that a knowledge of the macrostructure of steel was usually as essential as a knowledge of its microstructure. The former gave the history of the steel in the ingot mould and during forging; the latter afforded information as to thermal treatment and composition, and enabled at the same time the details of the macrostructure to be correctly interpreted. The macrostructure of a cast metal was essentially due to segregation whilst solidifying, and it was convenient to consider such segregation to be of two kinds, which might be termed major and minor. Both were the result of the well-known phase law governing the solidification of a mixture of two or more mutually soluble constituents which stated that the first portions to solidify contained an excess proportion of the constituent having the higher freezing temperature, whilst the last portions to solidify contained an excess of the constituents having the lower freezing temperature. Mr. Humfrey then referred to sulphur printing and etching for revealing the macrostructure of steel and added that the strong relief effects produced by the acid solution suggested, at an early stage of the experiments, the possibility of reproducing the details of the etched surfaces by direct contact printing, *i.e.*, by means of printer's ink and a press. The illustrations of macro-etchings which accompanied the paper had all been so reproduced, the actual specimens being supplied to the printers, and here, he thanked the staff of the *Sheffield Daily Telegraph* for the assistance they had given him in the matter.

Dealing with unforged ingots, Mr. Humfrey further stated that the evidence due to former experiments made by Dr. Stead pointed very strongly to phosphorus as the most important of the impurities, and that evidence could not be put on one side without very definite experimental data to the contrary. He added that a slab of steel showing a well-marked dendritic structure was etched to a deep relief. The relief portions were then very carefully scraped away from the surface and the scrapings collected. The surface was then re-faced, and the process of etching and scraping continued until sufficient scrapings had been collected for analysis. Drillings from the slab showed the average composition to be, per cent., C. 0·51; Si. 0·13; Mn. 0·70; Ph. 0·040 and S. 0·041, whilst duplicate analyses of the scrapings gave Ph. 0·046 and silicon and manganese the same as in the average drillings.

Two prints in the paper illustrated the use of macro-printing and etching in studying the flow of metal during forging. They were from longitudinal axial sections of the base portions of two shell blanks. In the case of one, the punch used had a flat face and the flow of metal had taken place in such a manner as to produce a curious "cone" formation just beneath the base of the cavity in the forging. In the case of the other, the punch had a bluntly pointed nose, corresponding approximately to the outline of the said "cone," and the "cone" formation was entirely absent, the steel having spread out regularly before the punch as this advanced.

Professor A. McWilliam, who opened the discussion, said he was very much interested in the paper and congratulated the author upon the results he had obtained. To mention only one point of view, it was necessary in very many instances to put a mental picture in the mind of industrial workers in order to show them what took place inside the steel. He (the speaker) on several occasions, and by means of rough sketches, not to be compared with Mr. Humfrey's beautiful macrographs, had endeavoured to bring home these intricacies to the mind of the Hindoo worker; his former experience with students at the Sheffield University had been valuable to him in connection with this illustrative work before workers in India. He would like to add, however, the opinion that in an ingot, as in a man's life, when a thing once occurred it never ceased to be, there was no getting it out. He (the speaker) examined the nature of the ingot as revealed at the top as a guide for the future work on that ingot. Their old friend, the late Dr. Sorby, was, he thought, the first to carry out work of this class, and he would have been delighted to have seen the author's results.

Dr. Hatfield, who followed, stated that the Sheffield steel makers had been in touch with Mr. Humfrey right through the war, and he had shown them, in particular, the work he was carrying out and which formed the subject of the paper. Macrography was equally as important as micrography, and Mr. Humfrey's achievements in regard to the former would assist in the production of full-size images. No fault could be found with the method followed. In many laboratories it would not be followed, and the specimens would be etched and photographed; but a photograph was not so satisfactory as a direct print, the photograph having light and shade effects. Dealing with the theoretical side, he (the speaker) suggested that one portion of the paper rather spoke with apparent knowledge of the distribution of the phosphorus, and Dr. Stead had also done so on former occasions, but he (the speaker) was not convinced that phosphorus was alone the element responsible for this macrostructure, several other elements being present in greater proportion than phosphorus and being more likely to explain the structure. The author had made use of the term "immobile carbide," which was important, and he asked whether it was used following upon experiments other than those referred to in the paper. Any carbide would diffuse readily in any iron at temperatures such as those the steels dealt with were exposed.

Mr. J. H. Whiteley said that macrography was a subject he had considered attentively and had put four or five years ago before the Cleveland Institution of Engineers. His reagent was very similar to Dr. Rosenhain's. He did not print his specimens, but rubbed in Chinese white and photographed them in a good light. The lines shown round the margin in the author's prints of ingots were pictured in his (the speaker's) specimens. They were due to the chill effect when the metal entered the mould. He showed on the blackboard the structure of his specimen, which was dendritic one side and granular on the other; he cut test specimens from each, which showed the same tensile stress but a different elongation. The granular structure was the result of the chilling against the mould. The author's method of printing the specimens was superior to his (the speaker's) own.

Dr. Rosenhain thought that a certain attitude of reserve should be held in regard to what caused the macrostructure. His impression was that the impurities which were present in the liquid state and remained in crystal solution gave rise to "minor segregation." How long the crystals persisted was not the complete question, but how much impurity was there to crystallise and then how much still remained in the metal. Oxide was one which could give rise to a dendritic structure to the metal as cast, a structure which would persist after hot mechanical treatment. Phosphorus had the same effect and other elements also. Taking the macrostructure was capable of application in many instances; it could show the extent of work put upon a piece and how the work had been applied. In rolled material, it could indicate whether a crack had developed before or after the last rolling. It was useful to establish such points and direct printing had many advantages. He was not surprised to see the effect of the square punch.

Dr. Stead stated that the paper would be a valuable one to metallurgists. As Professor McWilliam had said, it was also his (the speaker's) impression that Dr. Sorby was the first to make macro-prints from steel blocks, but they were different from those of the author in that cementite gave the pattern in the prints. Later, there were obtained the very same structures by sulphur, by a process called the auto-sulphur printing process. Dr. Stead added that if Mr. Humfrey had taken sulphur prints of his sections, he would have obtained the same structure, but reversely, the white becoming brown. Practically the same lines would have been shown in sulphur prints as those shown in Mr. Humfrey's prints. Mr. Whiteley's steel blocks were deeply etched and they could have been printed as had been those by Mr. Humfrey. The latter's process was an improvement. Dr. Stead further added that phosphorus was not the only impurity responsible for the "white elements" and made a sketch on the blackboard showing the different orientation to the surface of adjoining crystals; he pointed out how, when the surface was etched, some cube faces dissolved much more rapidly than others, there being a difference in solubility varying with the orientation. When a fine needle point was driven through a crystal, by etching the metal flowed away and a star-shaped hole appeared, this making it possible to find out the orientation of the crystal. From round, the hole in the reagent became perfectly square. Finally, he repudiated the idea that he had ever said that phosphorus alone made a difference in the solubility of different parts of steel; other elements came in also.

Mr. E. H. Saniter expressed the opinion that macrographs directly printed would be of great value to manufacturers, especially in regard to forged materials; in regard to ingots, the direct printing might perhaps be superfluous, as sulphur prints would suffice, since they showed the dendritic structure at the chill and the sagging centre. For smaller work and for forgings the printed copies showed the structure in greater detail than the sulphur prints. It would be advantageous to drop stampers to make such sections of their drop stampings to ascertain whether their dies were of the right shape. In a stamping which came to his notice a dead area was shown and the taking of a macrostructure would prevent that from occurring. Unfortunately, it was rather an expensive and long job to obtain and prepare a specimen of any size; there was also the danger of producing a false appearance if the greatest care was not used. Nevertheless, the method described in the paper was a most interesting one, and one that would prove most useful.

Mr. H. H. Ashdown said he felt under a debt of obligation to the author, and would like to express it at the meeting, as he had this process in detail passed on to him, and had found it most useful in investigating sections of large ingots. He was very pleased to see that the author had not continued to describe these reproductions as phosphorous prints. Some little time ago he had taken some of these etched sections which had been deeply etched, had had them scraped and analysis taken in duplicate. He had found in several cases the sulphur had come out considerably higher in proportion than the phosphorus. There was one case in particular which might be of interest, where the sulphur from the back of the disc was 0·026, and that from the etched scrapings came out 0.06, while the phosphorus rose only from 0·02 to 0·031. He was sure there was a great future before the method. He found it extremely useful in dealing with sections from very large ingots. It had been his privilege some years ago to be in charge of shell manufacture, and he could assure the author that to use a round-nosed punch was a retrograde step. In using a round-nosed punch owing to the excess pressure required, it was apt to bend, take a false lead, and much eccentric work would result. If after considerable use one examined a round-nosed punch and a square-nosed punch, one would see at once why much greater pressure was required. There was very heavy scoring all over the round-nosed punch, whereas with a square-nosed punch there was only evidence of friction flow past the shoulder, and in addition one got a direct push. With regard to the cones which had been found in the bases of shell, during his experience of shell manufacture he had had very many shells sectioned, and had never come across a cone, but he had one handed to him eighteen months previously, and from his examination he thought the author would find that it corresponded with the segregated cone in the ingot. He was disposed to think these cones, due to the applied pressure, slipped from the segregated area when the billets were punched on the cold side. During the war, owing to the great pressure in production, it was quite likely that many shell billets had been pierced at comparatively low temperatures, and what had actually happened was that the cone had been forced down from the segregated faces into the base. He did not think that provided the billets were punched at a comparatively low temperature, the round-nosed punch would obviate the coning taking place.

Mr. Humfrey, who stated that he would reply to the discussion by correspondence, was awarded the thanks of the meeting for his contribution.

THE ACID HEARTH AND SLAG.

The third paper taken at Friday morning's meeting was one on "The Acid Hearth and Slag," by Mr. J. M. Whiteley and Mr. A. F. Hallimond; it was read in abstract by the former. It dealt with the microstructure of slags, the structure of the acid hearth, and the reactions occurring in the molten slag during the steel-making process. We intend to print this paper in full in an early issue.

The discussion was opened by Mr. E. H. Saniter, who said he was greatly interested in this contribution to the proceedings; it contained a large amount of valuable information for steel-makers. The third section, dealing with the molten slag had attracted him especially, and he greatly admired the author's photomicrographs. He had a few remarks to make in regard to the sand used, and would add that during the war steel-makers had to adjust their figures to the material available. The authors had stated that there was wanted in the sand a higher percentage of silica than that revealed by a number of analyses, whilst he (the speaker) had had trouble before the war with a too refractory sand. Since the war, he had mixed together in equal quantities an inferior and a superior grade of sand, and had obtained thereby better results in the bottom of the furnace than formerly. The author's statement to the effect that the need for a sand of higher purity that would not fuse to a solid mass, but would retain its porosity at the temperature of the furnace, contained a large amount of truth. He repeated that the use of too refractory a sand would lead to trouble. An important point was referred to in the paper, in regard to the use of lime additions having a retarding effect on the rate of formation of magnetic oxide towards the end of the operation.

Dr. F. Rogers stated that in the open-hearth furnace the slag itself was of value, and if it were deoxidised too far there was a risk of sending back the phosphorus to the metal, and he would like the authors to give more information on the action of the lime in supplanting the iron oxide or minimising its formation towards the end of the process.

Dr. A. McCance said that he could only deal with one of the many questions raised by the authors, and that was the part which the atmospheric oxidation of the slag played in oxidising the carbon. The authors had ascribed this to Fe_2O_3 formed by direct oxidation of FeO, and which acted as a carrier of oxygen from the air to the molten bath of metal. But although the action was admitted, he (the speaker) did not think that Fe_2O_3 played any part in it as such, the real carrier of the oxygen being Fe_3O_4. The presence of magnetite in open-hearth slag discovered by himself and confirmed by the authors, gave obvious support to this view, but there were also other reasons. When considering this question some time ago, he had been anxious to discover whether open-hearth slag was oxidised by air, and for this purpose some finely ground slag was heated in a current of air at gradually increasing temperatures and the increase in weight measured. The slag contained to begin with 12·02 of FeO and 0·80 of Fe_2O_3; the increase in weight began at 500 deg. C. and reached a maximum at about 1,100 deg C., at which temperature the iron had become almost wholly ferric oxide, being 0·504 FeO and 14·40 Fe_2O_3; the percentage increase in weight at this temperature corresponded exactly to the increase in oxygen necessary for this conversion. The slag was non-magnetic, but on heating to higher temperatures it became magnetic, and the increase in weight diminished up to 1,300 deg. C., the highest temperature reached. This showed conclusively that Fe_2O_3 in air, above 1,100 deg. C. was decomposed and that it was the magnetic oxide which was formed. In addition to that evidence, he (the speaker) added theoretical considerations would point to the stable oxide as being the one with the lowest dissociation pressure, and at 1,500 deg. C. the dissociation pressures in mm. of mercury were roughly thus: $Fe_2O_3 \rightarrow Fe_3O_4$, 17 mm. and $Fe_3O_4 \rightarrow FeO$, 0·4 mm. All the evidence showed that Fe_2O_3 did not exist at the temperatures of steel-making. At the same time, while admitting that such an oxidising effect took place, he did not give it the importance which the authors did as a source of the unaccounted oxygen in open-hearth charges. He had examined in detail a great many charges, and had found that the unaccountable oxygen, expressed as a molecular percentage of the melted charge varied from 1·5 per cent. to 2·5 per cent., and although he had paid particular attention to the point, he had not found the figures to bear any relation which the ratio of the slag area bore to the weight of metal. In large, quick working furnaces with shallow bath and large slag area, the missing oxygen would just as often be low as high, and in the case of a deep bathed furnace with a small area of slag, it would just as often be high. The temperature of working the charge was of more importance than the slag area exposed to the flame. The missing oxygen, he further stated, came from two sources—it was carried into the slag from the air through the action of Fe_2O_3, or it was abstracted from the metal by the diminution in the amount of FeO in solution. All the evidence he had collected on the point led him to believe that the second source was more important than the first, and that it accounted for more than 50 per cent. of the total missing oxygen.

Dr. Stead, who closed the discussion, stated that the relations between the slag and the steel in the bath required close study, and the author's paper was one of the best the Institute had received on the subject. Research was always rewarded. The large amount of iron oxide in the sand at the bottom of the furnace was remarkable, as also was its concentration in the ganister bricks of the roof, and the large amount that could be found in the silica bricks without rendering them fusible. He was very glad to see the younger metallurgists coming forward so effectively, and added that if their example were followed in other industries, this country could hope to go steadily forward in competition with other nations.

On the motion of the chairman, the authors received the hearty thanks of the meeting for their paper.

The last sitting was held during the afternoon of Friday, the 9th inst., when in the absence of the President, Dr. Stead occupied the chair.

SOME POINTS IN THE MANUFACTURE OF FILES.

The first paper was one entitled "Some Points in the Manufacture of Files," by Mr. G. Taylor, who read it in abstract. It reviews in detail the composition of the steel used for making files, the forging of the blanks, their annealing and straightening, grinding, cutting and hardening. We hope to reproduce it in full in a forthcoming issue.

Professor H. M. Howe, who opened the discussion, said that the conditions governing file-making were among those which should be studied in detail by a competent research body. The subject was one of particular importance, and one which required diligent research. To mention one point only, the making of a file suitably hard without conferring brittleness at the same time was a process which necessitated the most careful adjustments of temperatures. He hoped the author's example would be conducive to the carrying out of systematic research, for the matter was of considerable scientific and practical interest.

Dr. T. Baker stated that at the same time as he received a copy of the paper, he had under observation a question of defective files, and the defects he found in these were the same as those mentioned in the paper. The strips for making the files had been rolled at a much too high temperature; the fracture was very coarse and crystalline, and a very simple micro-examination showed an extremely coarse cementite network which had not resulted from the hardening process, but was in existence at an earlier period. It was quite clear that in the manufacture of files there was room throughout for improvements. There was much room also for information on the subject, and the paper gave that to the file-maker, together with data on the scientific method of making files.

Dr. F. Rogers, by means of a diagram on the black board, showed at what ranges the heat treatment operations could be carried out for more rapid and accurate working.

Dr. Stead stated that he had once ground down a file smooth and had etched it, when he had found the roots of the teeth to be all troostite, whilst the spaces between the roots were martensite, a remarkable illustration of troostite and martensite located side by side. In annealing there was a point where one got the divorce of pearlite. The coarse structure could be broken down by care in the heating. He emphasised the value of the paper, the first one to be read on the subject for the last fifty or sixty years.

Mr. Taylor, in the course of a brief reply, expressed his satisfaction at having been able to bring the subject to the notice of the Institute, adding that file-making ought to receive attention, inasmuch as it had been neglected in past years. It was time that this subject and other kindred subjects also were looked into, and an attempt made at standardisation, so that the reference "made in Great Britain" again occupied its place in the markets of the world, a place which ought never to have been lost. It was difficult to convince Sheffield file-makers of the inadvisability of leaving files in the furnace until they became stone cold. If the processes mentioned in the paper were adopted, the output would be increased very largely indeed. He had been disappointed in producing the paper, for there was a large amount of matter he would have liked to include, and he had been limited to space; he hoped, however, to publish a book dealing exhaustively with the subject.

The author received the thanks of the meeting for his contribution to the proceedings of the Institute.

THE MANUFACTURE AND WORKING OF HIGH-SPEED STEEL.

The next paper taken was one on "The Manufacture and Working of High-Speed Steel," by Dr. J. H. Andrew and Mr. G. W. Green; it was read in abstract by the former, who stated that it described in full the practice followed in this connection by their firm, Messrs Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw, Manchester. We commence the reproduction of this paper on page 668 of the present issue.

Professor H. M. Howe thought the Institute should feel deeply gratified at the frank way in which the processes of the manufacturers had been put before the meeting; this was typical of the times, it being recognised that all should help one another. During the war, interesting information had been very freely imparted, and that the same spirit was persisting was very welcome. With regard to the size of ingots, the impression had grown that increase in dimensions was to be guarded against owing to a corresponding increase in inter-dendritic segregation. Years ago, tyre blanks had been cut out of large ingots, but long since each tyre was made out of one single ingot. Firms had, also, put down large slabbing mills, the installation costing millions of dollars, for the manufacture of large boiler plates by shearing, but it had been found out since that the making of smaller ingots each one for one plate was by far the better practice. The casting of larger ingots in which solidification took place more slowly than in the case of smaller ones gave rise to the inter-dendritic segregation he referred to.

Professor C. A. Edwards also thanked the authors' firm for the open way in which they had permitted their results to be put forward, for it was frequently very difficult to obtain satisfactory information outside the works. He could endorse the authors' statement as to the difficulty with which the special carbides could be eliminated, since he had had the same trouble in the case of chromium steel and chromium-tungsten steel almost carbonless. He would like complementary information on the authors' heating and cooling curves. In regard to these, the authors had stated that if the steels cooled from 1,145 deg. C. and 1,300 deg. C., respectively, were compared, it was noted that the latter presented a larger evolution of heat at the critical point, and the resulting product was harder;

they added that there must be some radical change in constitution between the temperature of 1,145 deg. C. and 1,300 deg. C., this agreeing with Yatsevitch, who found that the higher the initial temperature, the higher the evolution at the critical point and the greater the hardness. If reference was made to the curves referred to, he (the speaker) added, the information given was not sufficient to deal with the matter. In order to see whether at a critical point the evolution of heat was larger than at another, the rate of cooling at the critical point had to be known. The curves showed that retardation in the rate of cooling tended to increase the magnitude of the critical point. It was possible at certain rates of cooling in the case of special alloy steels to have a distinct carbide segregation from the solution according to the rate at which they were cooled. He was pleased to see that the authors found the secondary hardness to persist; there was no dip in the curve at intermediate temperatures and he was glad that the authors' view supported his own.

Mr. H. H. Ashdown greatly appreciated the practical value of the paper; this showed that Manchester was remaining in the forefront in the manufacture of tool steel. He was astonished that the authors had noticed no difference between rolled and forged steel, and stated that machining tests with hammered bars showed these to last onger than rolled bars.

Dr. F. Rogers said that some of the information contained in the paper was known in Sheffield; the files at the Sheffield works' offices would show that very similar processes were in use there. He asked for a few particulars with reference to the Brinell hardness numbers quoted in the paper, and explained that a pair of tools could be taken and treated simultaneously with different results, or with consistent results if the pieces were put with the noses together in the furnace. Hardening whether in air, oil or water was a very sensitive operation, and it was difficult to measure and to control the temperature at the same time.

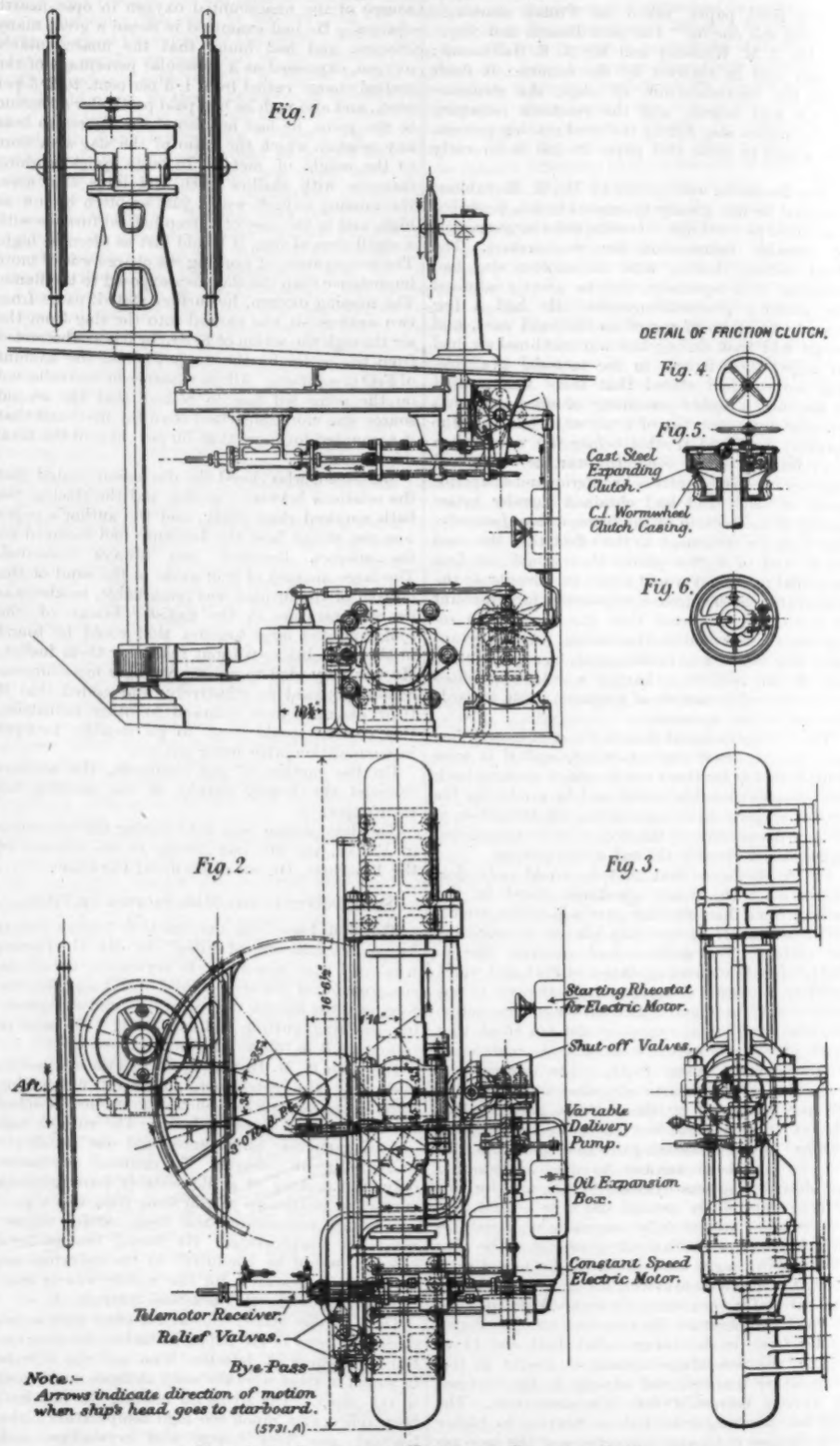
Dr. Hatfield questioned the authors' suggestion that the "white constituent" was carbide of iron. Other investigations with tungsten steel, for example, which had involved a large amount of work showed the "white constituent" to be tungstide. The "white constituent" in question was the seat of a great deal of trouble in high-speed steel, and it was useful, therefore, to thoroughly discuss what it really was.

Mr. C. G. Carlisle, who followed, questioned the authors' temperatures in their table of casting data as compared with their hardening temperatures. As to whether the "white element" which had been referred to was carbide or tungstide, he was not prepared to say. Two micrographs showed a difference in structure when treated respectively at 1,300 deg. C. and 1,305 deg. C., a difference of only 5 deg. C. There must be here something wrong in the temperatures. Segregation in the ingot persisting in the finished bar would be in the centre of the drill, and reach the point of the latter, and his own work showed the segregation to be there markedly in crucible steel, less so in electric steel, and he was surprised that the latter steel had not been dealt with by the authors. In cutting tests with tools made both of crucible and of electric steel, he had obtained, undoubtedly, the best results with those made of electric steel. In regard to segregation, the authors should refer to this as chemical segregation and not carbide segregation. Larger ingot sizes did not cure the segregation trouble.

Mr. H. J. Slagg said that before leaving America he had been impressed with the conservatism of British steel-makers, and was agreeably surprised to find at the meeting of the Institute such a paper as that of the authors. He agreed with the last speaker that a difference of 5 deg. only could hardly be responsible for a difference in the grain size of two specimens, but, he added, the time effect came in as well as the temperature effect. He (the speaker) did a large amount of work in America for milling cutters among other tools, he upsetted the bar and after the treatment he had always obtained good results, segregation had almost completely disappeared.

THE WILLIAMS-JANNEY VARIABLE SPEED GEAR.

(*For Description, see opposite Page.*)



FIGS. 1 TO 6. ELECTRO-HYDRAULIC STEERING GEAR.

On the motion of the chairman, the authors were accorded the thanks of the meeting for their contribution.

IMPROVEMENTS IN THE CASE-HARDENING PROCESS.

The last paper taken was one on "Improvements in the Case-Hardening Process," by Mr. D. Hanson and Mr. J. E. Hurst. It was read in abstract. It stated that ordinary methods of case-hardening at or above 900 deg. C. tended to lead to the formation of a hyper-eutectoid layer in the case, which was a frequent source of flaking and grinding cracks. In nickel case-hardening steel containing up to 3½ per cent. of nickel, the practice of refining at a temperature lower than the carburising temperature tended to aggravate this trouble. Trouble from this cause might be avoided by (*a*) quenching the steel from a temperature at which the excess

APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE SPEED GEAR.

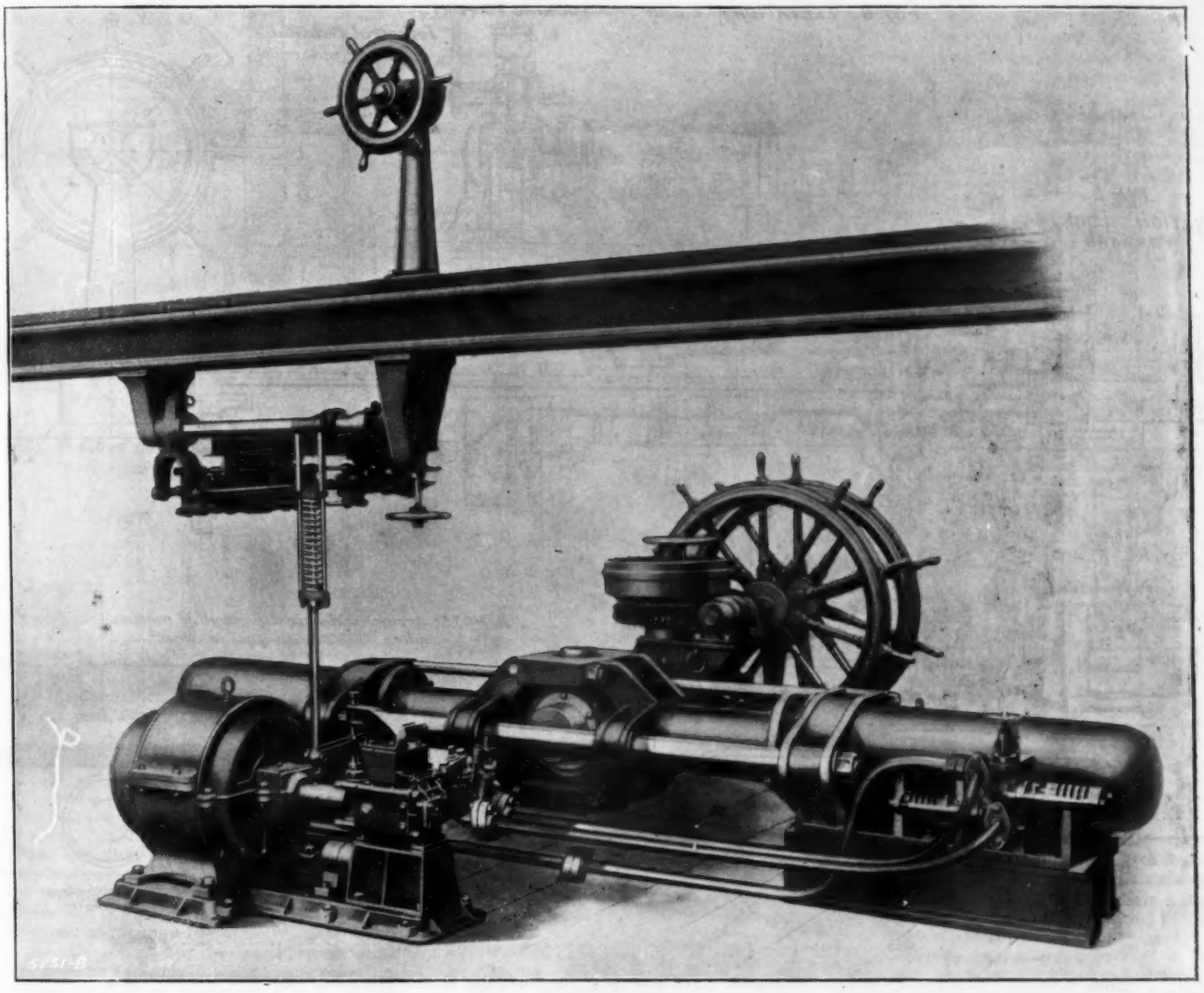


FIG. 7. ELECTRO-HYDRAULIC STEERING GEAR FOR OIL-TANK SHIP.

of carbide was dissolved; (*b*) modifying the treatment during carburising in such a manner that a case of practically eutectoid composition was obtained. Of these methods (*b*) was to be preferred. A simple modification of existing practice had been suggested by means of which this could be effected. Experimental evidence and an account of the successful working of the process on a works scale had been given. For 5 per cent. nickel steels a high carburising temperature appeared to be satisfactory.

Dr. Rosenhain found the subject dealt with a very interesting one, and the method of the authors a good one if carried out in a scientific manner. The paper would help case-hardening firms to get over their difficulties, if it were read aright.

Dr. F. Rogers, who referred to a diagram on the blackboard, showed at which point heating and quenching should be carried to get the cementite in solution.

Mr. C. H. Smith did not think the cementite was the cause of cracks, since he had seen a number of pieces containing free cementite in which there were no cracks. His main objection to the authors' process was the length of time it took. The authors had stated that in every case in which grinding cracks developed a sulphur content of over 0·1 per cent. had been found, and microscopic examination had revealed large quantities of sulphide; but he (the speaker) thought this could not be the correct explanation, for grinding cracks were purely due to mechanical action. If grinding were carefully done, there would be no cracks.

The authors received the thanks of the meeting for their paper.

The other papers on the list were taken as read; they will be discussed by correspondence.

The usual vote of thanks to the Institution of Civil Engineers for the loan of their premises, and to the chairman concluded the proceedings.

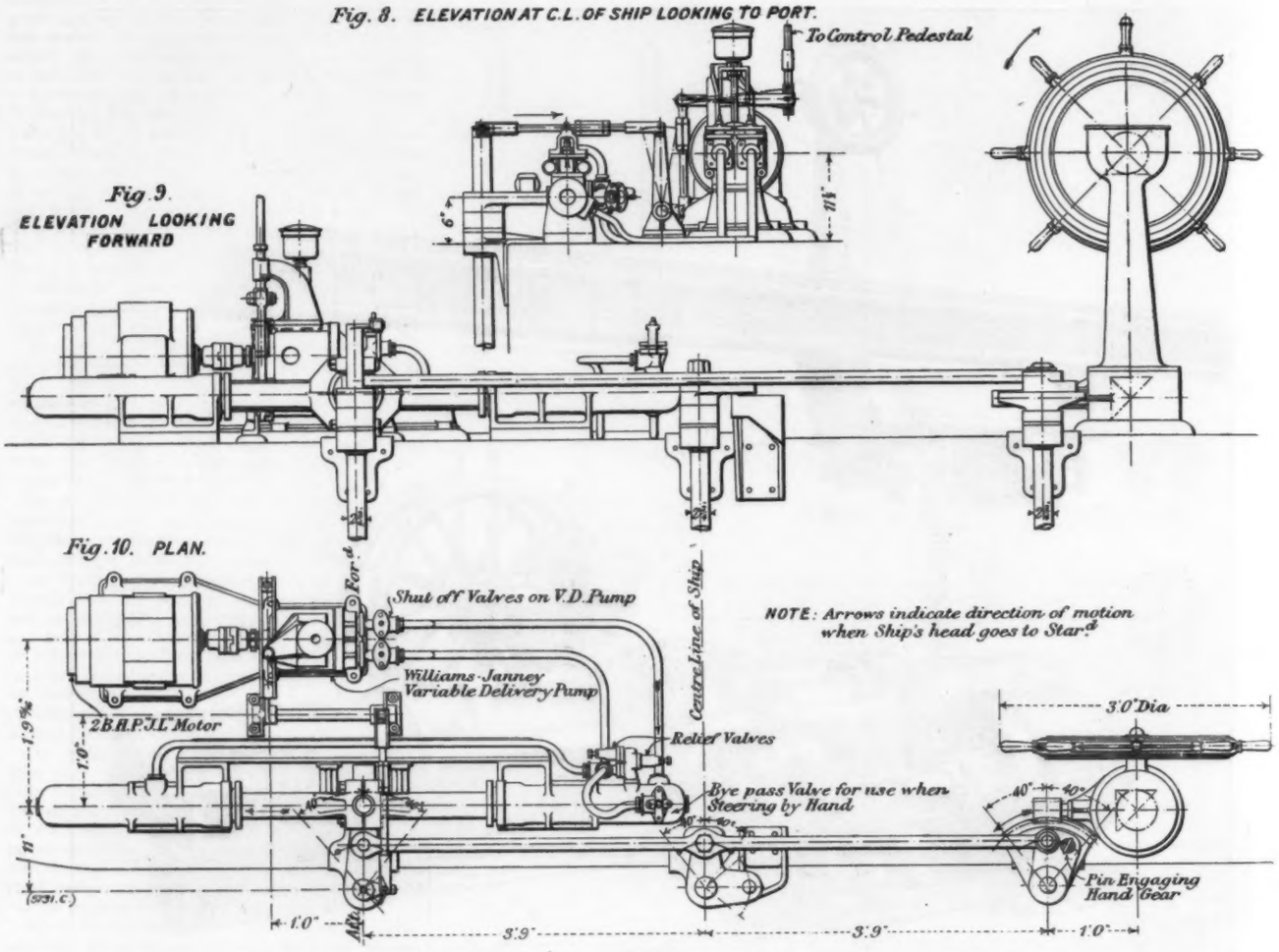
APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE-SPEED GEAR.

THE "Williams-Janney" hydraulic variable-speed gear, a detailed description of which appeared in ENGINEERING some six years ago,* is a device for transmitting rotary power at infinitely variable speeds and in either direction without stops or abrupt gradations, whilst the source of power rotates in one direction only and at constant speed. It consists of two similar hydraulic units, each of which comprises a group of cylinders mounted upon a shaft revolving in a fixed casing, one unit fulfilling the function of a pump and supplying fluid to the other, which acts as a motor. The pump end is driven at a constant speed, in one direction from the source of power, and means are provided whereby the stroke of its pistons may be varied, with the consequent result that the rate at which the fluid is delivered can be adjusted as desired from zero to the full capacity of the pump. The motor unit, or end, however, has a fixed stroke, and its speed depends upon the quantity of fluid delivered by the pump. By suitably controlling the stroke of the pump, the motor may be caused to rotate at any speed from that of the pump to zero. The stroke-controlling mechanism on the pump is further arranged to alter the relative positions of the pistons, and consequently to reverse the direction of flow of the fluid, with the result that the motor can be run in the backward position with the same range of speeds as in the forward position. The change from one speed to another is effected without any steps whatever, whilst in passing from the forward to the reverse direction on the motor the pump passes through the position of no stroke, and thus the change is made without any shock.

For a detailed description of the gear, reference must be made to our earlier article, but briefly it may be said that motor and pump units each consist of a casing containing a barrel keyed to the main shaft. In this barrel and parallel to the axis of the shaft a number of cylinders are formed. In each cylinder there is a trunk piston, the rod of which engages by means of a ball joint with a swash plate connected to the shaft by means of a universal joint. The whole arrangement revolves together and, as the swash plate maintains its plane of inclination, the result is that the pistons move in and out in the cylinders. In the pump unit the

* See ENGINEERING, vol. xcv, pp. 156–157.

APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE SPEED GEAR.



FIGS. 8 TO 10. ELECTRO-HYDRAULIC STEERING GEAR FOR SHALLOW-DRAUGHT MOTOR HOSPITAL SHIP FOR MESOPOTAMIA.

angle of the plane of inclination of the swash plate can be altered so that the stroke of the pistons, and consequently the amount of liquid supplied to the motor unit can be altered. In the motor unit the piston stroke remains constant, and the speed naturally depends on the amount of working fluid supplied by the pump. If the pump swash plate is moved until it is at right angles to the axis of the shaft the pump pistons have no reciprocating motion and no fluid is supplied to the motor, while if the swash plate is moved over beyond the right-angle position the motor unit cylinders are supplied with working fluid in the reverse order from before, and the motor unit reverses its direction of rotation.

There are two forms of this gear, one in which the pump and motor shafts have a common axis enabling the pump and motor ends to be combined in one machine with a common valve plate, and the other, in which the pump and motor ends are separate and connected by piping which may be of any reasonable length. In some cases, too, one pump end is used for driving two or more motor ends, for example, in petrol-driven vehicles one pump direct-coupled to the engine shaft drives two motor ends, each one of which is direct-coupled to the front sprockets, this arrangement dispensing with the differential as well as with the gear-box. It will also be obvious that the pump unit can be used alone, as a variable delivery pump, in combination with a single-acting or double-acting ram. The fluid used for transmitting the power being oil, in which all the working parts rotate, perfect lubrication is ensured. Moreover, those parts which are subject to load are automatically under forced lubrication by connection with the pressure part of the machine. The oil pressure in the cylinders varies directly as the torque acting on the motor end shaft, and the horse-power transmitted varies directly as the product of the oil pressure and the speed of rotation of the motor end shaft. The normal working oil pressure varies from 300 lb. to 500 lb. per square inch, but it may rise to 1,000 lb., or even 2,000 lb. per square inch, to overcome any unusual resistance, or to overcome the starting effort required. Under average working conditions the efficiencies vary between 80 per cent. and 85 per cent.

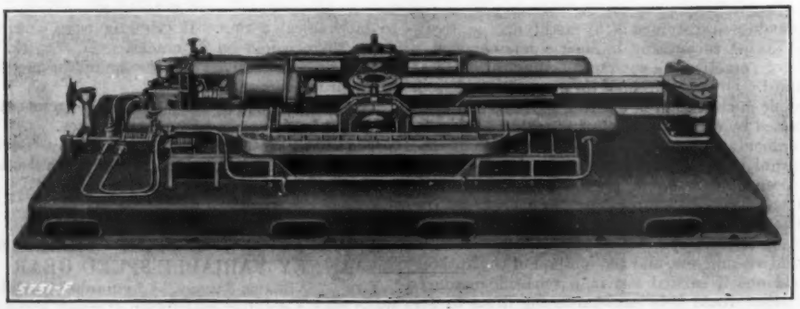


FIG. 11. GEAR OF RIGHT AND LEFT-HANDED SCREW TYPE.

The advantages to be derived from the use of these machines include flexibility owing to the infinite speed ratio obtainable, high starting effort, absence of wear and tear and upkeep, and the use of the simplest form of prime mover, *e.g.*, a shunt-wound, non-reversing motor, or alternating current, squirrel-cage motor. As showing the absence of wear and tear it may be stated that in numerous instances machines have been run continuously for

APPLICATIONS OF THE WILLIAMS-JANNEY VARIABLE SPEED GEAR.

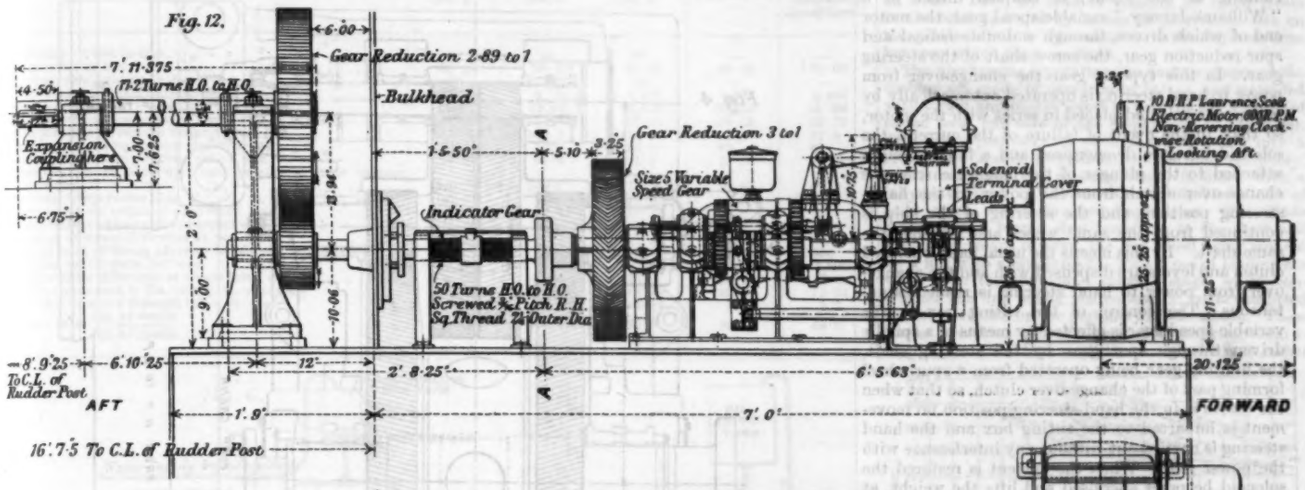
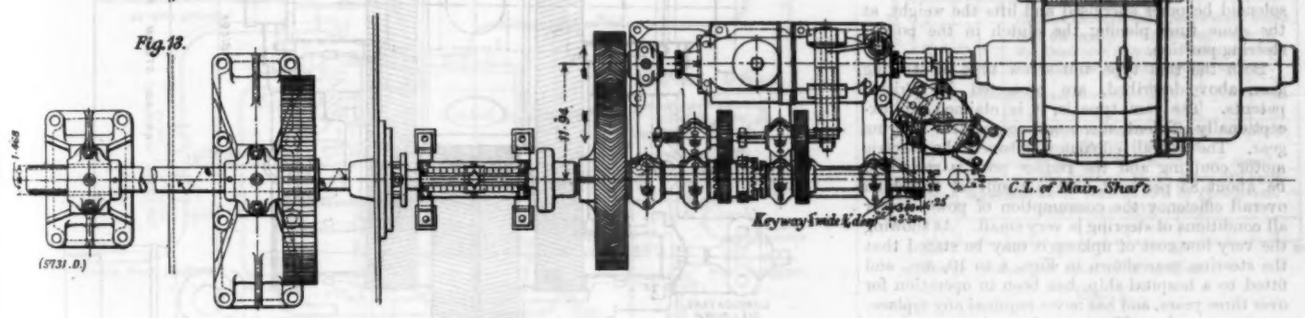
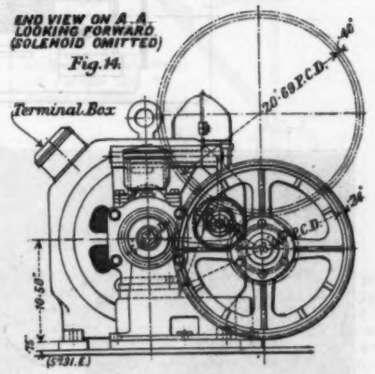


Fig. 12.
Gear Reduction 2·89 to 1
Bulkhead
Gear Reduction 3 to 1
Size 5 Variable Speed Gear
Indicator Gear
Solenoid Terminal Cover Leads
10 B.H.P. Lawrence Scott Electric Motor 600 R.P.M. Non-Reversing Clockwise Rotation Looking Aft.
Expansion Couplings
50 Turns H.O. to H.O. Screwed ¾" Pitch R.H. Sq. Thread 2½" Outer Dia.
AFT
FORWARD
16'. 7·5 To C.L. of Rudder Post



two years and more before being dismantled, and that on examination they have been found to be in as good a condition as when they were first installed. The operation of the machines may be controlled by either one of two methods, namely, a hand wheel operating the tilting box or motor swash plate through a screw and nut, or a hand lever operating the tilting box by a reciprocating rod. Either type may, if desired, be operated by the pressure in the machine so as to provide for an automatic reduction of delivery as the oil pressure increases, thereby preventing the electric motor from being overloaded, or to ensure a constant oil pressure irrespective of delivery. The appliance is manufactured by Messrs. the Variable Speed Gear, Limited, of Broadway Court, Broadway, Westminster.

Coming to actual applications of the gear we may first deal with a number of examples fitted to the steering gears of ships. Figs. 1 to 7, on pages 662 and 663, show an electro-hydraulic steering gear of the ram type which was fitted in a large oil-tank vessel, in which a 20-h.p. constant-speed electric motor drives a "Williams-Janney" variable delivery pump delivering oil to either one or other of two cylinders with rams 10 in. diameter placed athwartships. The two rams are bolted together in the centre, so as to form a crosshead for a trunnion block which operates on a cylindrical arm forming part of the tiller, which is keyed to the rudder post. Each cylinder is provided with a spring-loaded relief valve which comes into operation when the load on the rudder exceeds a predetermined amount. A by-pass valve is also provided for use when working the rudder by means of the hand gear, the oil thus being able to circulate freely between the two ram cylinders. The gear is controlled either by telemotor from the bridge or by a mechanical standard placed on the deck immediately above the steering gear compartment. Either the telemotor or the mechanical control operates the tilting-box of the pump through a floating lever, which is also connected to the tiller so as to form a hunting gear. In the event of the rudder being struck by a heavy sea or being subjected to any abnormal load, the oil pressure in the cylinders rises sufficiently high to lift the relief valves, thereby enabling the oil to pass from the cylinder under pressure to the other cylinder, thus allowing the rudder to yield to the blow, and so relieve the ship of any undue strain or shock. This movement of the rudder causes the hunting gear to move the tilting box of the pump through a sufficient angle, or in other words puts sufficient stroke on the pistons, to supply the requisite amount of oil to restore the rudder to its original position. The hand-steering gear consists of two brass-bound teak wheels mounted on a worm shaft, which drives a worm wheel forming the outer casing of a friction clutch, the inner member of which is keyed to a shaft carrying at its lower end a spur pinion gearing with a rack bolted to the after side of the tiller. The hand-steering wheels are put in and out of gear by means of a small hand wheel on the top of the hand-steering pedestal.



FIGS. 12 TO 14. STEERING GEAR OF RIGHT AND LEFT-HANDED SCREW TYPE.

A further example of an application of the variable-speed gear is given in Figs. 8 to 10, on page 664, which show an electro-hydraulic steering gear of the ram type which was fitted to a shallow-draught motor hospital ship for use in Mesopotamia. This vessel, on account of its shallow draught, and the swift flow of the rivers in that country, was equipped with three rudders. The steering gear was fitted, as shown, on the port side to suit the arrangement of the ship. The electric motor is of 2 brake horse-power, running at a constant speed of 600 r.p.m. on 115 volts, driving a "Williams-Janney" variable delivery pump, delivering oil to either of two rams, 3½ in. diameter, placed athwartships. The ends of the two rams are bolted together to form a crosshead for carrying a trunnion block which works on an arm of the tiller on the port side rudder post. The middle line and starboard side rudders are also worked from this tiller by means of a steel link. On the tiller of the middle-line rudder an extension is formed for carrying a locking bolt by means of which the three rudders can be locked in their midship position. Relief and by-pass valves are provided in the ram cylinders as described above. The gear is controlled from the bridge by means of the usual wheel and light steel shafting. The hand gear consists of a 3-ft. diameter brass-bound teak wheel which works a steel worm through two sets of mitre gears in a brass pedestal; the worm in turn operates a bronze sector which is put into gear, when required, with the starboard rudder post by means of a pin. A general view of a somewhat similar type of gear to the above is shown in Fig. 11, on page 664. Nothing in detail need be said of this arrangement as its features will be sufficiently clear from the figure.

An installation of a somewhat different class

is illustrated in Figs. 12 to 14, on page 665, which show the power unit of a steering gear of the right and left-hand screw type. The illustrations show a typical gear in which a 10-h.p. electric motor running at 600 r.p.m., is coupled direct to a "Williams-Janney" variable-speed gear, the motor end of which drives, through a double helical and spur reduction gear, the screw shaft of the steering gear. In this type of gear the change-over from power to hand steering is operated automatically by means of a solenoid placed in series with the motor, so that, in the event of failure of the current, the solenoid becomes de-energised and a falling weight attached to the plunger of the magnet carries the change-over clutch from the power to the hand-steering position, and the steering of the ship is continued from the same wheel and through the same shaft. By this means the usual hand-operated clutch and levers are dispensed with and the change-over from power to hand steering is made instantaneous. The control of the tilting box in the variable-speed gear is effected by means of a spindle driven through spur gear by the steering shaft, the hunting gear being operated from a spur wheel forming part of the change-over clutch, so that when the clutch is in the hand-steering position no movement is imparted to the tilting box and the hand steering is carried out without any interference with the power gear. When the current is restored the solenoid becomes energised and lifts the weight, at the same time placing the clutch in the power-steering position.

Both the ram type and screw type of steering gear above-described, are protected by British patents. The ram type is, it is claimed, an exceptionally efficient, silent and economical steering gear. The overall efficiency between the electric motor coupling and the rudder post is stated to be about 85 per cent. As a result of this high overall efficiency the consumption of power under all conditions of steering is very small. As showing the very low cost of upkeep it may be stated that the steering gear shown in Figs. 8 to 10, &c., and fitted to a hospital ship, has been in operation for over three years, and has never required any replacements or repairs. The type of steering gear shown in Figs. 12 to 14 is that best adapted for use with the well-known right and left-hand type of steering gear, or for vessels in which the space available is not sufficient for the ram type. Over 100 examples of this type of steering gear have been supplied to H.M. Government, and private yards, and have in every case given complete satisfaction.

(To be continued.)

WESTINGHOUSE-RATEAU MARINE GEARED TURBINE INSTALLATION.

Two interesting marine geared-turbine installations have recently been supplied by the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester, for the steamships Assiout and Amarna, of the Moss Steamship Company, Limited, of Liverpool. The boats were built by the North of Ireland Shipbuilding Company, of Londonderry, of which Mr. Trevisa Clark is the managing director. The consulting engineers were Messrs. Wm. Esplen and Sons, of Liverpool. The first of the ships, the Assiout, has been completed some months, and the second, the Amarna, has recently completed her trials and been handed over. The ships have a length between perpendiculars of 370 ft., a moulded breadth of 51 ft., and moulded depth to upper deck of 28 ft. 2 in., and to bridge deck of 36 ft. 2 in. The deadweight is 7,200 tons, with draught 23 ft. 11 in., and the speed 11 knots.

It is mainly in connection with the machinery that we are concerned in this article. This, in each case, consists of a Westinghouse-Rateau turbine with independent high and low pressure cylinders, and giving a shaft horse-power of 2,500. The turbine is supplied with steam at 180 lbs., and 100 deg. F. superheat, and runs at 3,000 r.p.m. The vacuum is 28½ in. Steam is supplied from three single-ended marine type boilers, 15 ft. in diameter, and 11 ft. 9 in. long, having a heating surface of about 6,741 sq. ft., and a grate surface of about 156 sq. ft. The boilers are fitted with Schmidt superheaters. The propeller runs at 70 r.p.m., and between the turbine and propeller shaft there is a double helical reduction gear stepping down from 6 to 1 in the first stage and 7.1 to 1 in the second. The gear was constructed by the Power Plant Company, Limited, of West Drayton, Middlesex. The condenser is of the surface type, and is bolted direct to the low-pressure cylinder exhaust flange. It has 2,118 sq. ft. of surface, and is built up of ¾-in. diameter tubes, 18 S.W.G. thickness. A centrifugal circulating pump by Messrs. Drysdale and Co., Limited, of Yoker, Glasgow, is fitted, and a dual air pump by Messrs. G. and J. Weir, Limited, of Cathcart, Glasgow. Two Westinghouse vacuum

WESTINGHOUSE-RATEAU MARINE GEARED TURBINES.

THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING CO., LTD.

Fig. 4.

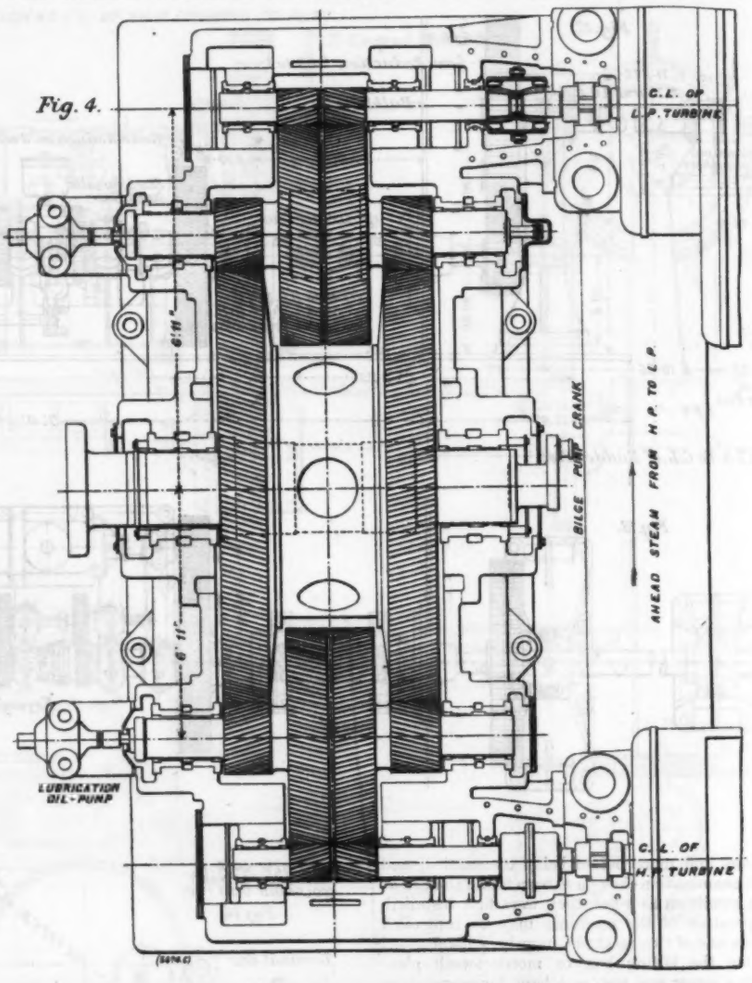
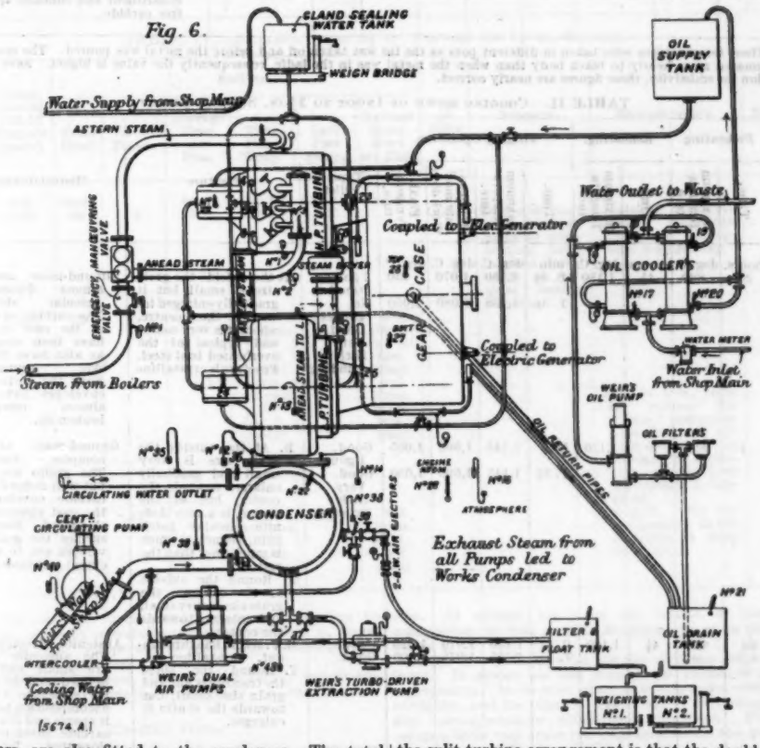


FIG. 5. GENERAL VIEW OF TURBINES.

RESULTS OF CONDENSER TESTS.

—	Official Test. No. 1.	Official Test. No. 2.	Official Test. No. 3.	Condenser Guarantees.	Full load Test corrected to Guarantee Conditions.
Duration of test in min.	60	45	60	—	—
Barometer in ins.	30·10	30·20	31·20	30·00	30·00
Free air temperature in deg. Fahr.	75	70	75	—	—
Load on set in shaft horse-power	1,043	1,763	2,427	2,500	2,500
Steam quantity in lbs.-hours	14,388	22,109	29,126	25,500	25,500
Vacuum at turbine exhaust, barometer 30 in., in ins.	27·76	27·49	27·01	28·50	28·70
Temperature at turbine exhaust, deg. F.	102·8	105·9	114·8	92·0	87·4
Cooling water temperature, inlet, deg. F.	81·2	77·0	83·9	60	60
Cooling water temperature, outlet, deg. F.	90·17	91·9	101·2	73·6	73·6
Temperature at condenser inlet calculated from vacuum observed	105·10	109·0	115·0	92·0	87·4
Hotwell temperature, deg. F.	87·65	92·5	111·25	—	—
Vacuum at air outlet of condenser, ins.	27·88	27·62	27·18	—	—
Temperature of gases at condenser outlet, deg. F.	85·62	84·4	101·2	—	—
Dryness of steam (calculated), per cent.	92·0	91·7	91·0	89·25	89·2
Latent heat of steam (dryness as above), B.T.U.-lbs.	950	945	935	927	930
Cooling water, galls. per min.	2,600	2,410	2,660	2,900	2,900
Temperature difference at steam inlet, deg. F.	14·93	17·1	13·8	18·4	13·8
Steam condensed in lbs. per sq. ft. of surface	6·79	10·44	13·75	12·04	12·04
Velocity of water through tubes, ft. secs.	4·75	5·24	5·7	5·7	5·7
Water ratio $\frac{\text{lbs. of water}}{\text{lbs. of steam}}$	108·5	65·4	54·8	68·2	68·2

Fig. 6.



ejectors are also fitted to the condenser. The total weight of the main machinery is 72 tons, distributed as follows :—

	Tons.	Cwt.
Turbines	20	0
Reduction gear	38	0
Main condenser	8	18
Circulating pump	2	0
Dual air pump	1	12
Vacuum ejectors and extraction pump	1	10
Total	72	0

After this brief general description of the plant, reference may be made to some of its features more in detail. In Figs. 1 to 3 in Plate LIII are given views showing the general lay-out of the machinery in position on board ship. As will be seen the two turbine cylinders are made quite independent from each other, and drive each through a separate pinion. By means of this arrangement each turbine acts as a standby to the other, suitable steam connections being provided so that each turbine section can be operated by itself while the other is shut down. These connections are clearly indicated in the figures on the plate. Normally, of course, the two turbine sections operate in series. Each turbine is fitted with a reversing element at its forward end, these elements also normally working in series, but being capable of being worked independently in case of emergency. A relatively high reversing power of 60 per cent. to 70 per cent. is obtained under normal conditions. A further advantage of the split turbine arrangement is that the double pinion drive allows of the employment of a lighter type of gear than would be necessary if the whole power were taken through a single pinion. The gear is shown in plan in Fig. 4 on page 666, and a general view of the turbines is given in Fig. 5. The double reduction adopted makes the gear a comparatively simple mechanical proposition compared with that which would be presented were the reduction from 3,000 r.p.m. to 70 r.p.m. made in a single step.

The turbines themselves do not greatly differ in general construction from those built by the Westinghouse Company for use on land. The casings are made of high-grade cast-iron, as in the high pressure cylinder the internal pressure is not more than 30 lb. to 40 lb. per square inch, and even this pressure is limited to the first stage and does not extend throughout the cylinder. High pressure is confined to the nozzle box, which is a very important part of the turbine owing to the large pressure drop and conversion of energy which takes place in the nozzle. The Westinghouse Company have recently introduced a new design of nozzle box which is of much interest. Owing to the large range of temperature and pressure to which the nozzle box is subjected, especially when reversing, it is important that it should be allowed to expand and contract freely without throwing any stress on the turbine cylinder, or reducing the clearance between the nozzles and the first row of moving blades. This is accomplished by supporting the box at the inlet and only allowing the other end complete freedom of movement. The arrangement is a great improvement on previous methods. The nozzle box is a steel casting, while the nozzle block is built up of forged steel angles machined all over, between which the guide plates which form the nozzles are inserted. The guides are made from special steel and are machined all over. They are held in position by fitted rivets at the inlet end and by means of projections left on the guides to fit into recesses made in the angle sections between which they are fixed.

The diaphragms separating the various stages of the turbine are made of cast-iron in halves, and provided with spigot and socket joints to prevent the leakage of steam from one side of the disphragms to the other. The outer periphery of each diaphragm fits into a recess machined in the cylinder and the inner periphery, which embraces the rotating shaft, is fitted with a labyrinth gland. The nozzles, or guide blades, are of mild steel cast into the diaphragms. The blade wheels are of forged steel forced on to the shaft and driven by means of keys, the last wheel being secured by a nut with a fine thread. Two types of blading are used. For the compound velocity stage, which constitutes the first stage, blades with T. roots are fitted into slots turned on the periphery of the wheel. These blades are short and this method of securing them is employed as the distance between the wheels is rather

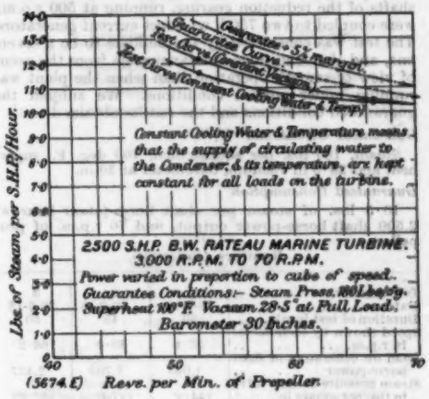

Guarantee + 5% margin.
Guarantee Curve.
Test Curve (Constant Vacuum).
Test Curve (constant Cooling Water & Temp.)
Constant Cooling Water & Temperature means that the supply of circulating water to the Condenser, & its temperature, are kept constant for all loads on the turbine.
2500 S.H.P. B.W. RATEAU MARINE TURBINE.
3,000 R.P.M. TO 70 R.P.M.
Power varied in proportion to cube of speed.
Guarantee Conditions:- Steam Press. 180 Lbs/Sq. Superheat 100°F. Vacuum 28·5 at Full Load. Barometer 30 Inches.
Lbs. of Steam per S.H.P./Hour.
(5674 E) Revs. per Min. of Propeller.

FIG. 7.

small for the employment of the straddle type of construction which is used for the longer blades of the Rateau stages. These Rateau blades are formed with a heavy root in which a slot is milled; they fit over the edges of these discs and are secured by rivets in double shear. All the blades are made from 5 per cent. nickel steel machined from the solid bar.

The main shaft is stepped in diameter from the centre towards the ends to take the blade wheels. As will be clear from the figures, the distance between the bearings is small and the critical speed is well above the normal running speed. Combined water and steam sealing glands are employed where the shaft passes through the cylinders. The water gland is normally used for continuous operation at sea. It is of the centrifugal type, an impeller maintaining a water seal in its race. The steam gland is of the labyrinth type and is incorporated for use during manœuvring, starting and stopping. The main bearings are of cast iron in halves lined with white metal. They are separated from the glands by small isolating chambers in order to prevent them becoming heated from the cylinders. Each main shaft is fitted with an overspeed device which prevents racing by tripping the emergency valve in case of speed rise above the normal. Although there is no end thrust in the turbine, thrust collars are fitted to maintain the rotor in the correct position relative to the cylinder.

The lubrication of the turbine is carried out in conjunction with the lubrication of the gearing. It is probably not too much to say that the maintenance of adequate and continuous lubrication of the gearing is the most important matter necessary to the successful operation of a marine geared turbine job. In the case of the sets we are dealing with a combined gravity and pressure system is used. A continuous circulation of oil is maintained from a drain tank below the engine room, through strainers and coolers, to an oil supply tank which is fitted as high as possible—above the top engine-room grating. The oil is forced up by means of two Roto-plunge pumps carried at the ends of the intermediate shafts of the gearing, as shown in Fig. 1. A Weir steam-driven oil pump acts as a standby. The coolers are supplied with water from the main circulating system or can be changed over on to one, or other, of the ship's pumps. The pipe connections are shown in the figures on the plate, while a good general idea of the lubricating system is given by Fig. 6 annexed which shows the plant as laid out in the builder's works for carrying out tests. If necessary,

the supply tank can be cut out and the oil pumps supply direct to the bearing and gears. The oil is fed to the high-speed gear trains by means of oil shields which ensure uniform distribution in either direction of rotation. The low speed trains are lubricated by means of sprays.

As has already been said, and as is shown in the figures, the condenser is bolted direct to the low-pressure cylinder exhaust flange giving a very compact and self-contained arrangement. The condenser lies athwartship and the path followed by the steam between the last row of blades and the condenser tubes is very short and of a section which reduces exhaust loss to a minimum. In addition to the Weir air pump and extraction pump two Westinghouse steam ejectors are fitted which serve as a standby to the air pump. The main thrust block is of the Michell type. The main dimensions of the plant are as follows:—

	Ft.	in.
Fore and aft over turbines and including thrust block	25	6
Height, tank top to shaft centre	6	6
Height, tank top to top of turbines	11	0
Athwart over outside of turbines	22	10
Athwart h.p. and l.p. turbine centres	13	10

In the tests on the plant, of which the lay out already referred to, is shown in Fig. 6, the intermediate shafts of the reduction gearing, running at 500 r.p.m., were coupled to two 750 k.w. direct current generators. The test was considered by the builders to be a severe one, and the conditions less favourable from the point of view of smooth operation than when the plant was running under normal conditions. We subjoin the guaranteed conditions and the results obtained:—

Guaranteed Conditions.

Steam, 180 lbs. per square inch, 100 deg. F. superheat and 28·5 in vacuum, barometer at 30 in.

Guaranteed Consumption

10·5 lbs. of steam per shaft horse-power hour at 2,500 shaft horse-power output, and 70 r.p.m. of propeller.

RESULTS OBTAINED.

Test number	1	2	3
Date	30-6-18	30-6-18	30-6-18
Duration of test in min.	60	45	60
Speed shown by tachometer in r.p.m.	52·4	60·0	66·2
Load on generators in shaft horse-power	1,043	1,763	2,427
Steam pressure at stop valve in lbs. per square in.	144·4	147·0	167·23
Steam temperature at stop valve, deg. Fahr.	446·0	455·0	464·0
Superheat at stop valve, deg. Fahr.	83·0	90·0	90·0
Vacuum in turbine exhaust (barometer 30 in.)	27·76	27·49	27·01
Total steam consumption in lbs./hours	14,388	22,109	29,126
Steam consumption per shaft horse-power hour in lbs. per shaft horse-power hour	13·79	12·54	12·00
Steam consumption corrected to guaranteed conditions (constant vacuum)	12·20	11·04	10·49
Ditto (constant cooling water and temperature	11·60	10·70	10·40
Guaranteed consumption from curve	13·0	11·6	10·8

The above results are plotted by curves in Fig. 7 on page 667.

Some condenser tests were also carried out on the same day as the tests recorded above. Details of results are given in the table on page 667.

THE MANUFACTURE AND WORKING OF HIGH SPEED STEEL.*

By J. H. ANDREW, D.Sc. (Chief of the Metallurgical Research Department, Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw), and G. W. GREEN (Assistant in the Metallurgical Research Department, Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw).

UPON the theoretical side of high-speed steels information is not lacking. Osmond, Bohler, Arnold, Carpenter, Edwards, Swinden, Honda, Yatesvitch and others have dwelt at some length upon the question of tungsten and chrome tungsten steels from a scientific standpoint. The only papers, as far as the authors are aware, dealing with the subject from a practical point of view are those of Taylor-White and J. M. Gledhill.

It was thought that it might be of some interest to present an account of more recent practice of high-speed steel manufacture.

In this paper an attempt is made to show the practical applicability of scientific methods to high-speed steel practice, following through the steel from the state of ingot to the finished tool, and to show the changes that are brought about by the varying treatments.

The paper itself deals with four particular ingots of A.W. steel which were followed through every process, observations being made of times and temperatures of carrying out each particular operation, along with a micro examination of the steel after each successive treatment. The ingots chosen for this purpose were 6 in. square chills about 3 ft. in length.

It must be stated that the figures given represent the practice as carried out at the Openshaw Works of Sir W. G. Armstrong, Whitworth and Co., Limited.

In order to present all the phases occurring in the practical working of the steel it was decided to treat all four ingots in different fashions. A table representing the operations undergone by the ingots that were followed is given in the third column of the opposite page.

In order to make it easier to follow the various data obtained during the operations of mechanical and heat treatment of these ingots, the results have been tabulated under different heads. The separate tables will only be dealt with briefly as they are self-explanatory.

The pyrometer used was the Cambridge optical, standardised by the National Physical Laboratory. This pyrometer was found in practice to yield exceedingly reliable and concordant results, the results being slightly on the low side owing to the impossibility of obtaining perfect black body conditions.

A comparison made between the pyrometer in question and a calibrated thermocouple working in connection with a Paul indicator, gave the following results, and shows that a correction of plus 20 deg. C. is required when employed for furnace temperatures.

Temperatures taken in Water-Cooled Port of Basic Open-Hearth Furnace.			Temperatures taken in Tool Steel Hardening Furnace.		
Optical.	Thermo-couple.	Correction for Optical.	Optical.	Thermo-couple.	Correction for Optical.
deg. C.	deg. C.	deg. C.	deg. C.	deg. C.	deg. C.
1,100	1,120	+20	1,130	1,150	+20
1,140	1,160	+20	1,130	1,155	+25
1,215	1,230	+15	1,140	1,160	+20
1,240	1,255	+15	1,110	1,140	+30
1,300	1,320	+20			
1,340	1,355	+20			

The above temperature comparisons are representative of a large number.

TABLE I.—CASTING DATA.

No.	Size of Ingot.	Weight.	Time of Casting.	Temperatures. In Pots.*	Temperatures. Ladle.	Stripped. Time.	Stripped. Temp.	Type of Ingot.	Annealed. Time.	Annealed. Max. Temp.	Fracture, Microstructure, and Macrostructure.
A1	6 sq. in.	cwt. 3¼	20 sec. 0·55 ton per min.	deg. C. 1,410 1,420 1,430	deg. C. 1,340	min. 30	deg. C. 650	Good	hours. 48	deg. C. 800	The following particulars relate only to A4 and after annealing.
A2	6	3¼	17 sec. 0·62 ton per min.	1,410 1,420 1,420	1,330	30	650	Good	48	800	*Fracture.*—Trans crystalline. Crystal grains are large. No chill crystals, but signs of chilling right to the centre.
A3	6	3¼	17 sec. 0·62 ton per min.	1,410 1,440 1,440	1,330	30	650	Good	48	800	*Macrostructure.*—No dendrites whatever. No sign of chilling. The carbide boundaries are in relief.
A4	6	3¼	18 sec. 0·58 ton per min.	1,400 1,430 1,420	1,330	30	650	Good	48	800	*Microstructure.*—Etched nitric. Near the ingot surface is a marked segregation of massive carbide. Shows eutectic structure. General structure, polygonal grains which increase in size towards the centre. The grain boundaries are of carbide. They become thicker and more discontinuous towards the centre and often show the eutectic structure. The ground mass is a dark etching constituent and contains specks of free carbide.

* These temperatures were taken in different pots as the lid was taken off and before the metal was poured. The conditions approximated more nearly to black body than when the metal was in the ladle, consequently the value is higher. Save for the correction for emissivity, these figures are nearly correct.

TABLE II.—COGGING DOWN OF INGOT TO 3½-IN. SQUARE BILLET.

No.	Preheating. Time.	Preheating. Maximum Temperature.	Reheating. Time.	Reheating. Maximum Temperature.	Forging Operation. Time.	Forging Operation. Maximum Temperature.	Forging Operation. Temperature most Work done	Forging Operation. Final Temperature.	Type of Billet.	Fracture.	Microstructure.
A1	hours. 24	deg. C. 820	hours. 4½	deg. C. 1,180	min. B. 6½ T. 3½	deg. C. 1,150 1,135	deg. C. 1,070 1,080	deg. C. 950 1,050	2 gouges. Good. No gouges. Good. Very little grinding.	At the outside the grain size is small but it gradually enlarged towards the centre, where it is very coarse and typical of the overheated tool steel. Fracture is crystalline.	Ground-mass austenite almost decomposed. Acicular structure. The carbide envelopes of the cast structure have been elongated, as also have the carbide segregations. Near the surface the envelopes have been almost completely broken up.
A2	4	820	5	1,170	B. 4 T. 3½	1,145 1,145	1,060 1,090	1,005 1,030	Good. 1 gouge. Good. Very little grinding.	B. At the outside the grain size is very small and gradually enlarges towards the centre, but at the centre, is a very definite circular patch (1 in. diameter) which is much finer than the rest. T. Round the outside of the fracture the grain size is very small and enlarges towards the centre.	Ground-mass of decomposing austenite. The grains are small but well defined. The carbide envelopes of the cast structure are elongated. Near the surface the grain envelopes are, to a large extent, obliterated.
A3	24	820	4½	1,180	B. 4½ T. 4	1,150 1,155	1,070 1,075	1,020 1,000	Good. Good.	B. Fracture fine throughout. Crystalline T. Round the sides the fracture is fine and grain size small, but towards the centre it enlarges.	Austenite decomposing. The austenite grains are small and well defined, and the acicular structure of the decomposition product is sparse and fine. The carbide envelopes are elongated. Near the surface the grain envelopes are broken up to a great extent.
A4	18	750	1 hr. 23 min.	1,160	B. 5 T. 4½	1,100 1,110	1,020 1,080	980 1,040	Good. 4 gouges. Fair.	B. and T. Fine crystalline at both ends with no enlargement of grain size to the centre.	Austenite decomposing irregularity; hardly taken place near the grain boundaries, which are elongated. Grain boundaries broken up near the surface.

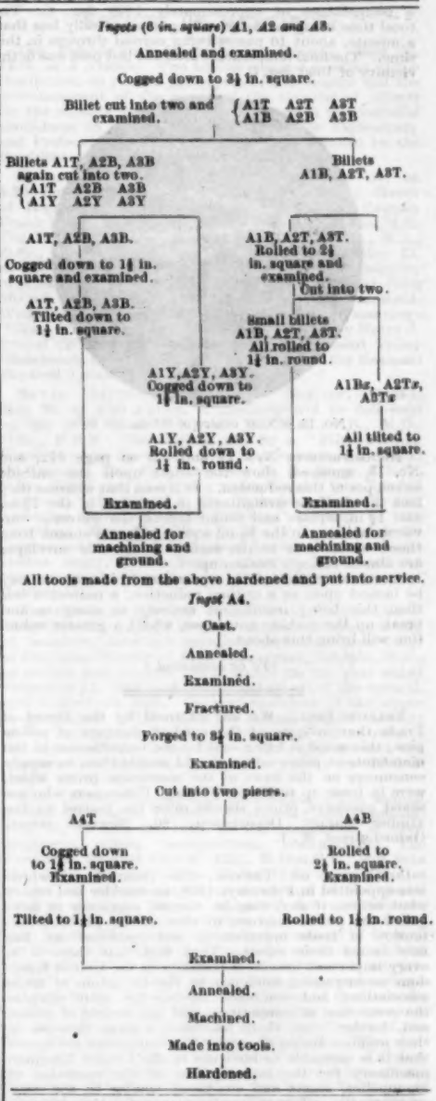
* Paper read before the Iron and Steel Institute, on Friday, May 9, 1919.

TABLE III.—COGGING FROM 3½ IN. SQUARE TO 1½ IN. SQUARE.

No.	Forging 1st End. Time.	First Temp.	Last Temp.	Forging 2nd End. Time.	First Temp.	Last Temp.	Type of Forging.	Fracture.	Microstructure.	Brinell.
	min.	deg. C.	deg. C.	min.	deg. C.	deg. C.				
A1T	2	1,150	1,090	1½	1,130	1,100	Very good. No grinding required	Similar to hardened tool steel fracture.	Austenite decomposing. The carbide envelopes are elongated into lines. A few segregations. Free carbide distributed irregularly.	
A1Y	2	1,140	1,090	1½	1,150	1,110	,,	Very fine crystalline showing traces of overheating. Hardened tool steel fracture.	Austenite decomposing. Shows acicular structure. Some fine carbide lines.	
A2B	2	1,160	1,110	1½	1,150	1,110	,,	Very fine crystalline with few traces of overheating. Hardened tool steel fracture.	Austenite decomposing. Free carbide in irregular globules and as "lines" and segregations.	
A2Y	2	1,170	1,090	1½	1,135	1,110	,,	,, ,,	Almost pure austenite. Very slight decomposition. Carbide lines.	
A3B	1½	1,170½	1,130	1½	1,150½	1,110	,,	,, ,,	Austenite decomposing. Free carbide as dots and as "lines" and segregations.	
A3Y	2	1,155	1,100	2	1,150	1,100	,,	,, ,,	At surface pure austenite. Near centre austenite decomposing. Number of fine carbide lines.	

TABLE IV.—ROLLING FROM 3½ IN. SQUARE TO 1½ IN. SQUARE.

No.	Temp. Coming out of Furnace (Scale).	Rolling. Total Time.	No. of Passes.	Average Time per Pass.	First Pass Temp.	Last Pass Temp.	Average Temp. Drop per Pass.	Type of Billet.	Fracture.	Microstructure.	Brinell.
	deg.	secs.		secs.	deg. C.	deg. C.	deg. C.				
A1B	1,090	50	9	5·5	1,040	1,020	2	Good	Hardened tool steel fracture. Signs of overheating. Laminations. Remnants of original casting structure.	Austenite decomposing. Carbide envelopes elongated considerably.	
A2T	1,090	39	10	3·9	1,070 (2nd pass 1,100 deg. C. scaled)	1,050	5·5 (from 2nd to last pass)	,,	,, ,,	,, ,,	
A3T	1,110	47	11	4·3	1,000 (3rd pass 1,100 deg. C. scaled)	1,050	5·5 (from 3rd to last pass)	,,	,, ,,	Also at ¼ in. from the surface the "lines" and envelopes show an abrupt change in the amount of distortion which, near the surface, is very great.	
A4B	1,130	63 two delays	11	6·7	1,060 (3rd pass 1,090 deg. C. scaled)	1,010	6·6 (from 3rd to last pass)	,,	,, ,,	As A1B. The decomposition of the austenite is very irregular.	


Ingots (6 in. square) A1, A2 and A3.
Annealed and examined.
Cogged down to 3½ in. square.
Billet cut into two and examined.
A1T A2T A3T
A1B A2B A3B
Billets A1T, A2B, A3B again cut into two.
A1T A2B A3B
A1Y A2Y A3Y
Billets A1B, A2T, A3T.
A1T, A2B, A3B.
Cogged down to 1½ in. square and examined.
A1B, A2T, A3T. Rolled to 2½ in. square and examined.
Cut into two.
A1T, A2B, A3B. Tilted down to 1½ in. square.
Small billets A1B, A2T, A3T. All rolled to 1½ in. round.
A1Y, A2Y, A3Y. Cogged down to 1½ in. square.
A1Bx, A2Tx, A3Tx
A1Y, A2Y, A3Y. Rolled down to 1½ in. round.
All tilted to 1½ in. square.
Examined.
Examined.
Annealed for machining and ground.
Annealed for machining and ground.
All tools made from the above hardened and put into service.
Ingot A4.
Cast.
Annealed.
Examined.
Fractured.
Forged to 3½ in. square.
Examined.
Cut into two pieces.
A4T
A4B
Cogged down to 1½ in. square. Examined.
Rolled to 2½ in. square. Examined.
Tilted to 1½ in. square.
Rolled to 1½ in. round.
Examined.
Annealed.
Machined.
Made into tools.
Hardened.

In the case of forging temperatures, according to Burgess, a slight correction of about 20 deg. C. must be made. All temperatures recorded, however, are those actually observed.

In coal-fired furnaces, owing to the smoky conditions prevailing, no attempts were made at temperature determinations.

CASTING DATA.

After dead melting the metal from several pots was transferred into a ladle, from which it was teemed directly into the mould (top cast).

The temperatures of casting are naturally subject to various corrections, the temperatures taken in the pots being approximately correct. The temperatures of the metal in the ladle, on account of the surface not approaching black body conditions, are decidedly low, whilst the usual troubles from fume and emissivity errors are not accounted for.

The temperatures are, however, comparative.

The data—Table I—serve to show the great uniformity obtained in casting temperature. Moreover, the annealing given to the ingots immediately after stripping showed remarkable uniformity.

The annealing was carried out in a gas-fired furnace.

Ingot A4 was the only one from which a piece could be got sufficient for examination. The type of fracture, microstructure, and macrostructure are given in the last column of the table, whilst the photomicrographs 1 to 3 are taken from different parts of the annealed ingot, and afford some interesting data which will be considered separately.

MICROSTRUCTURE OF CAST INGOTS AFTER BEING ANNEALED. (Page 672.)

Micro 1, page 672, is the structure near to the edge of the ingot. Micro 2 is taken at 1 in. from the surface.

The white parts of these micros consist of the exceedingly hard double carbide of tungsten and iron (or, maybe, treble carbide of iron, chromium and tungsten). It is seen that, near to the edge, these carbide envelopes are moderately fine and surround the small crystal grains. Towards the centre the grains increase in size, whereas the carbide envelopes become more massive; right in the centre of the ingot they are of considerable size. At certain places in the centre of the ingot segregation of this carbide is apparent, as is shown in Micro 3.

Micro No. 4 was taken at the extreme edge of the ingot. It shows on this section an excessive carbide segregation. It is seen that this segregate ends very abruptly, and its place is taken by an exceedingly fine and homogeneously distributed structure. No. 5 is taken a little way from the edge and shows the dendritic structure exceedingly well.

The conclusions to be drawn from these micros are: firstly, that on the extreme edge excessive carbide segregations occur. Nearer in than this, a fine structure persists, whilst in the centre of the ingot the usual coarse-grained structure with the thick walls of carbide is prevalent. It will be interesting to follow up this structure and to observe how it is broken up by mechanical work.

COGGING DOWN OF INGOT TO 3½-IN. SQUARE BILLET.

The ingot after casting and annealing was cogged down to 3½ in. square under a 30-cwt. hammer and about 10 per cent. of the head cropped off. The results of the observations taken in this operation are given in Table II. Previous to the actual working of the metal the ingots were, before finally heating up for the forging operation, preheated in a gas furnace, being allowed about 24 hours to attain a temperature of about 820 deg. C.; they were then immediately transferred, without cooling, to a coal-fired reheating furnace, where, after a period of four to five hours, they attained a temperature of about 1170 deg. C. The time taken in forging varied between very small limits, and on an average was about 4½ minutes. The final temperature after all work was done was approximately 1000 deg. C. After this, as after every other operation, the billet was examined and any cracks apparent were gouged out by means of steel gouges. The type of fracture and microstructure are shown in the last two columns.

MICROSTRUCTURE OF 3½-IN. SQUARE BILLETS.

Micro 6 shows the structure near the surface, where the carbide envelopes are seen to be well broken up. Nearer to the centre of the ingot, however, where the carbide envelopes, due to the slower cooling, are thicker, they assume, after this treatment, varying shapes, and are most uniformly distributed.

Micro 7 indicates the appearance assumed by these carbide segregations, and No. 8 the appearance of the carbide envelopes, embedded as they mostly are in a ground-mass of semi-decomposed material.

Occasionally one comes across a patch entirely free from these carbides and almost austenitic in structure. It was noted that in nearly every case near to the carbide segregation there existed these patches of undecomposed material (see Micro 10).

COGGING DOWN FROM 3½ IN. TO 1½ IN. (Table III.)

After cutting into two the 3½-in. square billets, they were aired under the fire-bars and finally charged into a coal-fired furnace. No definite time can be given for soaking, the times varying according to the ability of the forge to cope with them; nor was it possible in any of the operations carried out in the coal-fired furnace to get any reasonable temperature measurements. Here again, as in all previous cases, a glance at Table III will show the great uniformity of the temperatures employed and the times in forging.

After forging one end the other end was charged into the furnace, followed, of course, by a similar forging.

All the forgings followed through were exceedingly good. Forging was carried out under a 1-ton hammer.

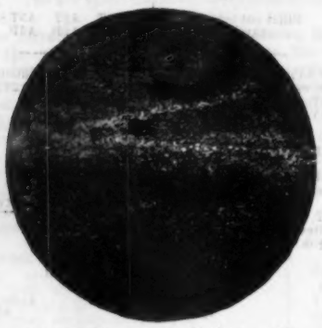
It must be remarked in passing that the term "overheating" in the fracture column is used to describe a typical kind of fracture common to overheated steel; it does not mean that the bars in question were overheated, but is merely used to describe large grain size.

Two microstructures are shown of bars after this operation, namely, Nos. 9 and 10, page 672. From Micro 9 it is seen that the carbide envelopes had become more laminated and broken up by this forging, whilst occasionally one came across a case, as depicted in Micro 10, of a semi-decomposed austenite.

ROLLING FROM 3½ IN. SQUARE TO 2½ IN. SQUARE. (Table IV.)

In all the rolling operations the bars were heated in a coal-fired furnace, being taken out of the furnace at

a temperature of approximately 1100 deg. C. The total time being taken for rolling was generally less than a minute, about 10 passes being carried through in this time. The final temperature after the last pass was in the vicinity of 1050 deg. C.



No. 13.—Near centre of billet. × 200.

Microstructures Nos. 11 and 12, on page 672, and No. 13, annexed, show the effect upon the carbide envelopes of this reduction. It is seen that whereas they lack the absolute straightness in direction of the 1¼-in. and 1½-in. square and round billets, the extreme curvature existing in the 3½-in. square billets is absent from these, whilst near to the surface the carbide envelopes are almost entirely broken up.

A reduction from 6 in. square to 2½ in. square may be looked upon as a critical reduction, a reduction less than this being insufficient entirely to elongate and break up the carbide envelopes, whilst a greater reduction will bring this about.

(To be continued.)

YELLOW PINE.—We are informed by the Board of Trade that in spite of the marked shortage of yellow pine, this wood is being sold by the Government to the merchants at prices which should enable them to supply consumers on the basis of the maximum prices which were in force up to March 31 last. Consumers who are asked excessive prices should refer the matter to the Timber Supply Department, 80, Newman-street, Oxford-street, W. 1.

COMMITTEE ON TRUSTS.—This committee, which was appointed in February, 1918, to consider and report what action, if any, may be deemed necessary to safeguard the public interest, in view of the probable extension of trade organisation and combinations, has now issued their report. They find that there is in every important branch of industry in the United Kingdom an increasing tendency to the formation of trade associations and combines having for their purpose the restriction of competition and the control of prices, and, further, that there has been a great increase in their number during the war. The committee are agreed that it is desirable to institute in the United Kingdom machinery for the investigation of the operation of monopolies, trusts and combines, similar to the commissions and other tribunals created for that purpose in the United States, and some of the British Dominions. When the committee was appointed Mr. Shortt, M.P., was chairman; when, in June, 1918, Mr. Shortt was appointed Chief Secretary for Ireland, he resigned the chairmanship and was succeeded by Mr. Charles McCurdy, M.P.

THE AREA OF SURFACES.—At the meeting of the Royal Society, held on May 15, 1919, a paper was read by Professor W. H. Young, F.R.S., "On the Area of Surfaces." Many attempts by well-known writers have been made to frame a theory of the area of surfaces. These efforts have been attended with so little success that even the most recent text-books define the area of a curved surface by means of the formula known to hold in the case of a surface of revolution. Not even in the matter of the definition itself has anything which can be regarded as final been achieved, still less has it been found feasible to proceed from the definitions which have been given to the formula required. In the present communication the author attacks the question from an entirely new point of view. The definition given is based on what is itself a new concept, namely, that of the area of a closed skew curve. It is characterised by the use to which is put the idea that the surface is, like a curve, an ordered manifold, the order being double instead of single. The surface is accordingly supposed defined by equations of the form $x = x(u, v)$, $y = y(u, v)$, $z = z(u, v)$, and divided up by the curves $u = \text{const.}$ $v = \text{const.}$ On the fact that the sum of the areas of the boundaries of the portions of surface thus obtained has a unique limit, the definition of the area of a surface is based. The curve boundaries have in fact an area whenever they possess a length. Moreover, the unique limit obtained for their sum is shown under very general conditions to have precisely the value given by the well-known formula. It may be added, though this is not proved in the paper, that the theory developed may be utilised to indicate the limitations of the older method, based on triangulation, and at the same time notably to extend such results as have been obtained by earlier writers.

SOUTH AUSTRALIAN WATER SUPPLY SCHEMES.

THE Royal Commission on Water Supply in South Australia, says *The Board of Trade Journal*, has presented further schemes for water conservation on a large scale, so that the residents of important towns and the large population represented by the settlers on the farming and grazing lands in the central and lower northern areas may have a permanent water supply. The latest proposals of the Commission relate to two schemes—at Spring Creek and Mount Remarkable.

The Spring Creek scheme, as designed by the hydraulic engineer, provides for a reservoir at Spring Creek, just below the junction of the White Mine Creek, capable of impounding 500,000,000 gallons, and, if necessary, double that quantity. The catchment area comprises 19 sq. miles, and reckoning a mean rainfall of 18 in., it is assumed that 212,000,000 gallons will be stored in an ordinary season. The springs from which the Wilmington water district is supplied yield 60,000 gallons daily, and this water would flow into the reservoir. After allowing for evaporation and absorption, it is estimated that 100,000,000 gallons would be available in an ordinary season from the catchment and springs to augment the supply from another reservoir to be constructed near Mount Remarkable. The hydraulic engineer's department selected a site for a reservoir on the Mount Remarkable Creek, with the object of constructing a concrete gravity dam to a height of 90 ft. above the bed of the creek for storing 266,000,000 gallons, on an estimated annual collection of 95,000,000 gallons.

COST.

The following summary shows the estimated cost of the two schemes—Mount Remarkable reservoir and a reservoir at Spring Creek—for the storage of 1,000,000,000 gallons :—

	£	£
Mount Remarkable Scheme, &c.		
Reservoir—Dam 93 ft. high; capacity 250,000,000 gallons	88,000	
Mains—74 miles	251,800	
Five per cent. interest during construction	16,990	
		356,790
Spring Creek Scheme, &c.		
Reservoir—Dam 119 ft. 6 in. high; capacity, 1,000,000,000 gallons ...	226,000	
Mains—13 miles	69,000	
Pumping station	16,000	
Five per cent. interest during construction	15,550	
		326,550
Total cost of both schemes ...		£683,340

The Commission recommend the carrying out of the Spring Creek and Mount Remarkable Creek scheme. It is recognised that the conditions arising out of the war will necessitate the revision of the estimates of the cost of construction of the two proposed reservoirs, and of the whole reticulation scheme.

BASIC STEEL PRODUCTION.—For the week ending May 17, 1919, a basic furnace at the Lanarkshire Steel Company's works, Motherwell, operating on cold stock produced eighteen charges, totalling 825 tons 2 cwt. The bath area of this furnace is 317 sq. ft. The same furnace yielded 732 charges in a single campaign.

STANDARD COPPER CONDUCTORS.—The British Engineering Standards Association has issued a list of British standard annealed copper conductors for electric light and power. The list is an extract from the revision of British Standard Specification No. 7, which will shortly be available. It deals with sizes up to 1 sq. in. area. The extract has been issued in order that immediate attention may be called to the reduction in the number of sizes and the omission of a wire gauge as a means of designating the conductors. Copies of the extract may be obtained, post free 2d., from the offices of the Association, 28, Victoria-street, London, S.W. 1.

PERSONAL.—Messrs. Vickers, Limited, state that recognising the importance to the trade of a ready source of supply of British made box-making and paper working machinery on a large scale, they have taken over the business of Mr. J. W. Nasmith, of Stockport, which they intend to develop as quickly as may be. Having ample means at their disposal for rapid production on an extensive scale, they hope in a very short time, not only to overtake the actual orders, but to be able to carry a stock in London of all standard machines of usual dimensions. As soon as may be the machines will be on view at their London rooms. —The partnership between Messrs. F. Gill and W. W. Cook, consulting engineers, of Winchester House, E.C., will be dissolved by mutual consent as from May 31, 1919. Mr. Gill, who for the last two years has been with the Ministry of Munitions, and is now Controller of the Central Stores Department, will on relinquishing that office on June 30 next, join the Western Electric Company as their European chief engineer.—We learn that Mr. V. S. Woods, who for forty years has been one of the directors of Messrs. A. Ransome and Co., Limited, has now retired from the firm. Mr. Lewis Ransome has been elected chairman of the company in his place, and Mr. E. Edis (the secretary), and Mr. F. W. Baker (the London manager), have now been elected to join the Board.—Mr. A. C. Leslie Guyer, who has just been demobilised from the flying branch of the R.A.F., has been appointed editor of *Aircraft*.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—This has been a broken week owing to yesterday's visit of the King and Queen, who were anxious to express personal appreciation for industrial Sheffield's war contribution, and also to note the transition to peace production. Evidence of the latter character Their Majesties found at Messrs. Cammell Laird and Co.'s Grimesthorpe works, where the mammoth castings and forgings excited keen interest. In consequence of the Royal visit many forges and foundries, and also some of the largest producers of finished articles, did not resume until this morning after the week-end set down, while, with very few exceptions, yesterday was observed as a general holiday. A scarcity of supplies, coupled with further advances in prices, are the chief characteristics of the iron market. Basic iron especially is in strong demand. Several new furnaces are to be put into blast to relieve the shortage of forge and foundry. Lincolnshire makers are asking 8*l.* 5*s.* to 8*l.* 7*s.* 6*d.* for basic, 7*l.* 12*s.* for foundry, and 7*l.* 10*s.* for forge. Derbyshire basic stands at the same level as the Lincolnshire product, foundry at 7*l.* 10*s.*, and forge 7*l.* 7*s.* 6*d.* Steel prices have advanced proportionately. Basic steel is about three times the pre-war price. In billets, Siemens acid are quoted at 17*l.* 2*s.* 6*d.*, hard basic 14*l.* 10*s.*, soft basic 15*l.*, and Bessemer 16*l.* 12*s.* 6*d.* Hoops are offered at 21*l.* to 22*l.*, and sheets at 25*l.* Railway reconstruction is providing a lot of work for carriage builders and makers of boiler tubes, as well as in rail, tyre, wheel and axle manufacture. The removal of half-yearly contracts is under consideration. Orders from the shipbuilding yards are plentiful. The demand for shipbuilders' steel and tools has shown a marked increase during the past month. Tramway departments are busy, and makers are well booked forward despite the fact that prices in some cases are quite three times those ruling before the war. Rails, for instance, formerly quoted at 6*l.* 10*s.*, are now making 19*l.* 10*s.* Pressure in the lighter trades increases. Small tools of all descriptions cannot be turned out fast enough. Orders are so plentiful that makers are able to exercise a certain choice, passing by the least attractive. The Netherlands are taking big quantities of small tools formerly supplied by Germany.

South Yorkshire Coal Trade.—The increase in industrial requirements brought about by the gradual unfolding of commercial trade, has further restricted the tonnage available for open market disposal, and the small quantity on offer is eagerly snapped up at maximum rates. A welcome improvement is reported in the output at the pits. This has enabled collieries to bring contract commitments nearly up-to-date. Best steam hards are in active demand by all classes of home consumers, and there is a fair amount going away on export account, despite restrictions. Foreign enquiries are more numerous than can be met while home trade is so brisk. Cobbles, nuts and slacks continue a strong market at top prices. Contractors take practically the whole of the output. The improved tonnages available have brought substantial relief to the house coal trade. Merchants have worked off the bulk of their arrears, and the position altogether is much easier. The continuance of warmer weather has resulted in a diminution in new business. Coke of all descriptions is a ready market and commands maximum prices. Values are firm at the following nominal rates :—Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Interest centres this week on the refusal once more of export licences for shipment. Of late no difficulty has been experienced in obtaining permits for shipment of pig-iron to foreign customers, but to prevent iron which is urgently needed at home being sent to foreign countries, applications for export licences are now being refused. This should, to some extent at all events, relieve the stringency in the home market. There is very keen competition to secure any small supplies of iron that become available from time to time. Producers are making every endeavour to distribute iron equitably among their customers, but their efforts fall considerably short of meeting the wishes of buyers. Practically the whole of the output of Cleveland pig to the end of June has been sold. Some July business has been done, and a transaction or two over the third quarter of the year have been recorded, but purchasers are not disposed to commit themselves further ahead. There are makers prepared to contract over the remainder of the year at current rates. For home consumption No. 3 Cleveland pig, and No. 4 foundry stand at 160*s.*, and though possibly rather less might be accepted, that figure is also generally named for No. 4 forge; whilst No. 1 is 164*s.* Export prices are now 5*s.* above the foregoing quotations.

Foreign Ore.—Trade in foreign ore is steadily expanding, but quotations vary very considerably, and are subject to freight rates. Many consumers are now coming forward to buy. Best rubio ranges from 45*s.* to 48*s.*, c.i.f. Tees, according to what steamers can be chartered at.

Hematite Iron.—Stringency in the hematite department is quite as pronounced as it is in the Cleveland pig branch. For the time being business is almost im-

possible. Output for some little time to come is bespoke, and few manufacturers will listen at all to further offers to buy. Those who can be induced to quote name 190*s.* for Nos. 1, 2 and 3 East Coast brands, and 192*s.* 6*d.* for No. 1.

Coke.—Coke keeps steady and firm with a good deal of business passing, a very ample supply meeting the substantial demand. Medium blast furnace quality is 39*s.* at the ovens; and low phosphorus sort 41*s.* 6*d.* at the ovens. Foundry coke for shipment to neutrals is 65*s.*; and gas house sort is 70*s.*

Manufactured Iron and Steel.—There is little new to report of finished iron and steel. Production tends to somewhat lower level, and demand for several descriptions shows falling off, but shipbuilding and railway material continue in good request. Enquiry from abroad is rather large, and includes rather substantial negotiations for supply to the Far East. Among the principal market quotations to home customers are: Common iron bars, 20*l.* 10*s.*; marked bars, 23*l.*; strip iron, 21*l.* 15*s.*; iron ship rivets, 27*l.* 5*s.*; steel ship, bridge and tank plates, 17*l.*; steel angles, 16*l.* 10*s.*; steel joists, 16*l.* 10*s.*; steel hoops, 23*l.* 5*s.*; and heavy steel rails, 15*l.* Similar rates also rule for export, except in the case of steel plates, which are quoted 18*l.*, f.o.b.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The past week has brought little in the way of change in the steel trade of Scotland, and indeed there seems little prospect of much alteration in existing conditions for the present. The high level of prices has a retarding effect, and business is almost wholly confined to immediate requirements. Buyers and sellers alike seem chary of fixing up much forward business, as the present position of the market is rather uncertain, and the result is that the former are only ordering their minimum necessities. Quite a number of large undertakings are being talked of as likely to come into the market in the near future, but the promoters having considered the position carefully, are of opinion that the present is not the most opportune moment to send out their inquiries. There are certain schemes which must be gone on with very soon, but wherever delay is possible the specifications are being tempo arily held over. Prices are unchanged, but with a hardening tendency, and a fall in values is not anticipated at present. The general inquiry is good, and order-books contain quite a respectable tonnage of various kinds of material. Ship and boiler plates continue in good request, and mills are kept well employed, while for structural material there is a fairly good outlet. The demand for steel sheets is of quite a satisfactory nature, and some decent lines have recently been picked up. In the export departments business is still somewhat slow, but a fair amount is being put through each week, although in this direction, prices and the matter of delivery, are tending to hold back any decided expansion. The foreign markets are crying for stuff, and will take a lot of satisfying, and so the future is considered as very hopeful once things begin to open out. Structural steel and railway material are both the subject of inquiry, but competition from foreign markets has to be faced.

Malleable Iron Trade.—In the malleable iron trade of the West of Scotland there is quite a lot doing, principally on home account, and works are well employed. Prices are firm and unchanged, and at the present values new business is slow. Particularly is this the case with export orders, although some improvement in this direction has already been noted, and the outlook is better.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade the demand continues, and makers are being kept very busy. Hematite iron is none too plentiful, and producers can hardly keep the steel-makers going. As supplies come forward, they go rapidly into consumption, with the result that stocks are nil. A similar state of matters exists with regard to foundry iron. The export trade is quiet, not but what there are numerous inquiries, but solely on account of the large home demand, which is absorbing so much at present, with the result that the shipping trade is rather limited. Prices are firm, and the tendency is for a higher level.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Markets.—A state of confusion has existed in the local coal markets since Monday, owing to a new Order of the Coal Controller, under which the Directions of October 26, 1918, were revised. Under the new directions a change in the prices for Allied countries (France, Italy, Belgium, Portugal, British Possessions, including coaling stations) is promised, and this part of the Order has brought business to a standstill, as operators are disinclined to undertake new business owing to the expectation that the promised alteration would mean that they would be able to obtain higher prices than the fixed figures now in operation. The three months' time limit for contracts has been removed, and a number of alterations made in the Schedule B prices under which neutral countries obtain their supplies. The provisions with regard to exporter's commissions and brokerage have been revised in the case of neutral business, and the effect of the change is the restoration of the customary claim of one-third of the 5 per cent. brokerage on freight to exporters. There are now five schedules of prices under which coal can be sold. In one case the schedule is a maximum, in another it is a fixed price, and in the other three the prices are minima. For home consumption the schedule is maximum; for Allied countries it is fixed; and for bunkers, Spain and South America and for Holland and other countries there are three different schedules. The following give an example of the different prices applicable to the coal trade:—

—	Bunker Minimum.	Allied Countries Fixed.	Spain and S. America Minimum.	Holland and Other Countries.
	s. d.	*s. d.*	*s. d.*	*s. d.*
Best Cardiff smokeless steams ..	40 0	40 0	50 0	75 0
Ordinary Western Valleys..	36 0	36 0	43 6	68 6
Steam smalls, No. 1.. ..	28 6	28 6	28 6	45 0
No. 2 Rhondda, large	34 0	34 0	41 0	66 0

It is anticipated that further important alterations in the matter of de-control of the coal trade will shortly be announced, and for this reason operators are holding off as much as possible. Collieries generally are fully stemmed, and buyers find it difficult to get even small parcels. Bunker coals continue to fetch from 5*s.* to 10*s.* above the minimum schedule for Allied steamers, and up to 15*s.* extra for neutral boats. Colliery salesmen yesterday held a meeting at Cardiff when it was suggested that a uniform price of 5*s.* and 15*s.* above the minimum should be charged to Allied and neutral vessels respectively. This proposal, however, was considered impracticable, and sellers were left to get the best figures they could. In the cargo section sellers were undecided as to what prices to indicate, and where figures were quoted they were considered to be unreasonable by buyers, and as a result new business was insignificant. The new directions of the Coal Controller has, to a large extent, wiped out the anomaly in the October schedule, under which the minimum fixed for Newcastle coals to neutrals was much higher than for South Wales fuels. This, it is expected, will result in more Scandinavian business going North. The Swedish Royal Navy some time ago asked for tenders for 9,000 tons of best South Wales steam coals to be delivered over the three months ended August. This order, it is now reported, has been withdrawn. Until details of the new prices for Allies is known it is not expected that there will be much business.

Newport.—The Monmouthshire market also has been idle on account of the new coal directions. Collieries generally are already fully booked up, and consequently there is only a little coal to spare. Where supplies are free it is mostly disposed of for bunkering purposes at from 5*s.* to 10*s.* a ton above the minimum for Allied steamers, and up to 15*s.* above for neutrals.

Strike at Cardiff Docks.—Since midnight on Saturday no vessel has sailed or arrived at the Cardiff Bute Docks, owing to a strike of lock foremen, berthing masters, dock gatemen and water men in consequence of a dispute as to the interpretation of the recent Railway Agreement. These classes of workmen have also struck at Penarth, but here vessels have been able to enter and depart from the docks. The alleged grievance of the men is that they are entitled to the full benefits of the Railway Agreement as members of the N.U.R., which contention is disputed by the company. The men claim that the guaranteed week of 48 hours should be spread over six days, and not seven as is being done, also that they are entitled to time-and-a-quarter for work done between 10 p.m. and 4 a.m. The matter has been discussed locally by both sides, and it now lies with the executive of the N.U.R. and the Railway Executive in London to state whether the men are entitled to what they ask. As the result of a telegraphic communication received late to-night from Mr. W. Hudson, M.P., Acting Secretary of the N.U.R., stating that negotiations were proceeding and that a settlement, when effected, would be made retrospective, the men decided to resume work at once.

Trimmers and Pooling Scheme.—The coal trimmers of Cardiff, Penarth and Barry have decided by ballot to adopt a general scheme for pooling their weekly earnings. The trimmers at Swansea and Port Talbot have also decided to dispense with the services of coal foremen, though they have no objection to private firms employing their own foremen providing they pay them themselves.

REINFORCED CONCRETE COASTER "VIOLETTE."—At the yard of Messrs. James Pollock Sons and Co., Limited, Faversham, Kent, there was launched on the 16th inst., the reinforced concrete coaster, Violette, length 125 ft., breadth 25 ft., and draft 9 ft. 9 in., having a deadweight of about 300 tons, and fitted with a 120 brake horse-power to 130 brake horse-power Bolinder direct reversible crude oil marine engine of the latest "M" model, which does away with the necessity of the injection of fresh water. The "M" model has recently been installed in a large number of large full-powered and auxiliary sailing vessels—some of them of 5,000 tons deadweight. The Violette is a sister vessel to the Molliette launched at the same yard in November last, and is a type of vessel that is finding great favour with shipowners owing to the low running costs. These benefits are still further increased if the construction is in steel, on which lines we understand Messrs. Pollock intend devoting their energies now that their war programme is completed. The Faversham yard is well laid out for installing auxiliary power to sailing vessels, also for repairs and alterations to existing craft. The Bolinder engine can be given delivery of from stock in all powers up to 320 brake horse-power to 350 brake horse-power, and only a few weeks' delay for 500 brake horse-power model.

NOTICES OF MEETINGS.

THE SURVEYORS' INSTITUTION.—Monday, May 26, 1919, at 5 o'clock. The annual general meeting of the Institution, to receive the report of the Council and the announcement of the result of the election of officers for the ensuing year. The prizes awarded to successful candidates in connection with the recent Preliminary and Professional Examinations will be presented by the President at the annual general meeting.

ROYAL SOCIETY OF ARTS.—Monday, May 26, at 4.30 p.m. Extra meeting: "A New Prime Mover of High Efficiency and British Origin," by Captain Frank E. D. Acland, R.A. (ret.), M.Inst.C.E., M.Inst.M.E. The Hon. Sir Charles Algernon Parsons, K.C.B., M.A., D.Sc., LL.D., F.R.S., will preside. Tuesday, May 27, at 4.30 p.m.: Colonial Section. "Science and Industry in Australia," by Lieutenant-Colonel the Hon. Sir John McCall, M.D., LL.D., Agent-General for Tasmania. Wednesday, May 28, at 4.30 p.m., ordinary meeting: "Glass-Making Before and During the War," by Harry J. Powell (Whitefriars Glass Works). Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S., Director of the National Physical Laboratory, will preside.

ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 30, at 5.30 o'clock, a discourse will be delivered by Sir John Rose Bradford, K.C.M.G., C.B., M.D., D.Sc., F.R.S. The subject will be a "Filter-Passing Virus in certain diseases." Afternoon lectures at 3 o'clock. On Tuesday, May 27. Professor W. H. Bragg, C.B.E., D.Sc., F.R.S., on "Listening under Water" (the Tyndall Lectures). (Lecture I.) On Thursday, May 29. Sir Valentine Chirol on "The Balkans" (Lecture I). On Saturday, May 31. Mr. J. M. Price, War-Artist Correspondent of the *Illustrated London News* with the Italian Army, "The Italian Front." Illustrated by cinematograph films lent by the Italian Government (Lecture I).

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, May 29, at 2.30 p.m. Annual general meeting of members, associate members and associates only, at the Royal Society of Arts, John-street, Adelphi, W.C., to receive and consider the accounts for the year ended December 31, 1918, and the annual report of the council, and to elect auditors. On the conclusion of the above meeting there will be held the annual general meeting of the contributors to the Benevolent Fund to receive the report of the Committee of Management and the statement of accounts and balance-sheet to December 31, 1918.

THE INSTITUTION OF GAS ENGINEERS.—The annual general meeting on Tuesday, Wednesday and Thursday, May 27, 28 and 29, 1919, at the Institution of Civil Engineers, Great George-street, Westminster. The President, Samuel Glover, Esq., M.Inst.C.E., will take the chair. Tuesday, May 27, at 10.30 a.m. Minutes of the last annual general meeting, and of the special general meetings, to be submitted for confirmation. Appointment of two scrutineers to examine the ballot lists for the election of officers and members of Council for the ensuing year, and of members, associate members and associates. The scrutineers' report will be presented at a convenient period during the proceedings. Address by the President. Presentation of the Council's annual report, 1918-1919, and statement of accounts for the year ended December 31, 1918. Report of the Gas Investigation Committee. Discussion. The proceedings will terminate at about 1.30 p.m. Evening at 8 p.m. Reception and dance by invitation of the President and Mrs. Glover at the Royal Institute of Painters in Water Colours, Piccadilly. Wednesday, May 28, at 10 a.m. Annual general meeting of the Benevolent Fund. After the meeting of the Benevolent Fund, the Institution's meeting will be resumed. Professor Arthur Smithells, C.M.G., will open a discussion on the "Education of a Gas Engineer." Report of the Refractory Materials Research Committee to be presented by the Chairman, Mr. A. E. Broadberry. Report of the Life of Gas Meters Research Committee. "The Internal Corrosion of Mains and Services," by Mr. J. G. Taplay and Mr. B. R. Parkinson. Paper on "The Application of Reinforced Concrete to Purifier Construction," by Mr. A. E. Broadberry, of Tottenham. Thursday, May 29, at 10 a.m. Paper on "The Interrelation of the Gas and Dye Industries," by Mr. W. B. Davidson, D.Sc., of Huddersfield. Paper on "Some War Experiences of British Gas Undertakings," by Mr. H. Townsend, of Wakefield. Replies to Question Papers. Nomination for election as honorary members:—The President of the Société Technique de l'Industrie du Gaz en France, the President of the American Gas Association, the President of the Associazione Italiana della Industrie Gas e Aqua. Place of meeting in 1920.

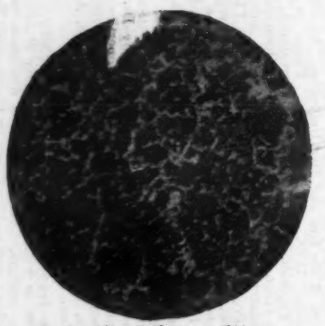
THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 30, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Discussion on the following paper will be resumed by Dr. Walter Rosenhain, F.R.S., "The Mechanical Properties of Steel, with some Consideration of the Question of Brittleness," by Mr. W. H. Hatfield, D.Met., of Sheffield, Associate Member.

THE ILLUMINATING ENGINEERING SOCIETY.—Friday, May 30, at 8 p.m., at the Royal Society of Arts (John-street, Adelphi, London), when a discussion on "The Gas-filled Lamp and its Effect on Illuminating Engineering," will be opened by Mr. F. W. Willcox.

THE JAMES WATT CENTENARY. *Erratum.*—In connection with our note on page 644 of our last issue, we find we were misinformed in reference to the contribution promised by the Birmingham Small Arms Company. The sum in question is 1,000*l.* not 5,000*l.*

THE MANUFACTURE AND WORKING OF HIGH-SPEED STEEL.

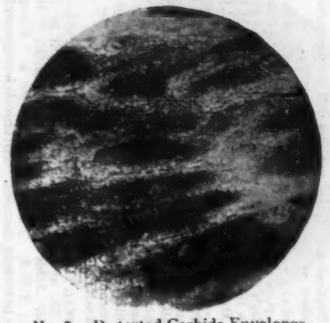
(*For Description, see Page* 668.)



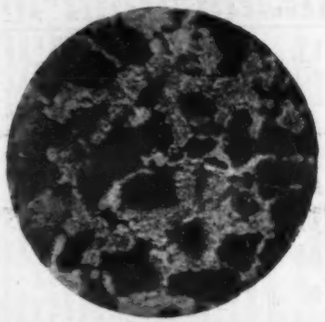
No. 1.—Near surface. × 200.

No. 2.—1 inch in from surface. × 200.

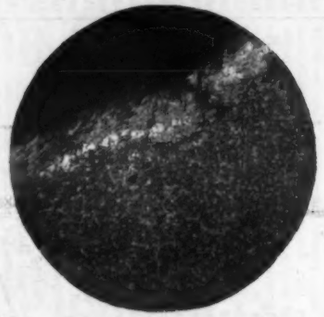
No. 7.—Distorted carbide segregation. × 200.



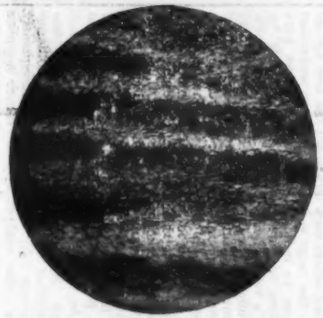
No. 8.—Distorted Carbide Envelopes. × 200.



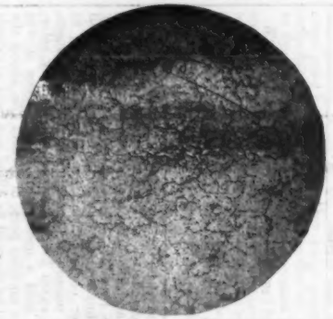
No. 3.—Carbide segregation near centre of ingot. × 200.



No. 4.—Extreme edge of ingot. × 200.

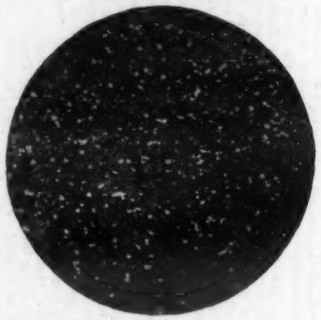


No. 9.—Showing lamination of carbide envelopes. × 200.



No. 10.—Showing semi-decomposed austenite. × 200.

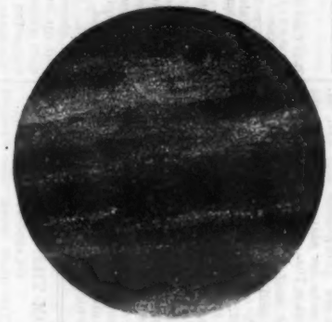
No. 5.—From near edge of ingot showing dendritic structure. × 200.



No. 6.—Near surface. × 200.

All reduced by one-third.

No. 11.—Near surface of billet. × 200.



No. 12.—Half way in. × 100.

All reduced by one-third.

EXPORT OF COAL.—The Board of Trade announce that in conformity with the policy of relaxing controls and facilitating the return to normal conditions, certain changes have recently been made in the conditions affecting the sale of coal for export, and it is now proposed, *inter alia*, to terminate the system of limited prices at present in operation in the case of coal shipped to France, Italy and other Allied countries.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—On account of Senatore Marconi having to return to Italy in connection with his military duties, the meeting which was to have been held on Tuesday, June 3, has been cancelled. Captain L. B. Turner's paper on "The Oscillatory Valve Relay: a Thermionic Device," will be read and discussed on Monday, June 30 (instead of Thursday, June 26).

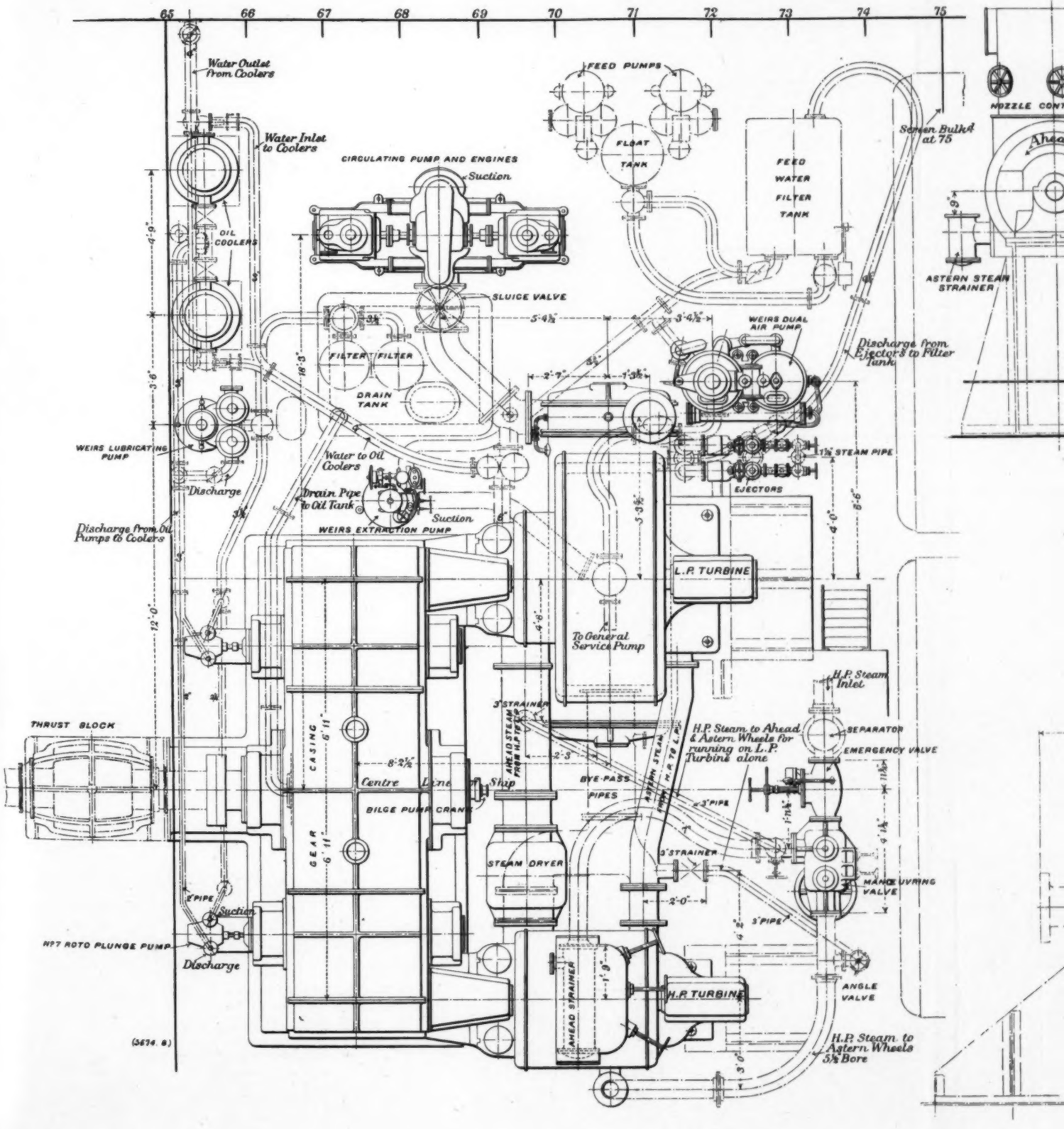
LAUNCH OF H.M.S. "WILD SWAN."—On the 16th inst., Messrs. Swan, Hunter and Wigham Richardson, Limited, launched from their Wallsend shipyard, H.M.S. Wild Swan, a very recent type of torpedo boat destroyer. She is the twenty-ninth destroyer taken in hand by this firm since the outbreak of the war. A year or two ago a destroyer like the Wild Swan was a leader of flotillas, but during the last twelve months a still larger ship has been built for the purpose. The armament of the Wild Swan will be more powerful than usual. There will be double tiers of guns both on the forecastle and at the after end of the ship, with other guns and torpedo tubes between them. The ship will be driven by a twin set of Brown-Curtis geared turbines, which, with the oil-fired watertube boilers, have been constructed by the Wallsend Slipway and Engineering Company, Ltd.

WESTINGHOUSE-RATEAU MARINE GEARED TURBINE

CONSTRUCTED BY THE BRITISH WESTINGHOUSE ELECTRIC AND MANU

(For Description, see Pa

Fig. 1.



USE-RATEAU MARINE GEARED TURBINES

CONSTRUCTED BY THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACT

(*For Description, see Page 6*

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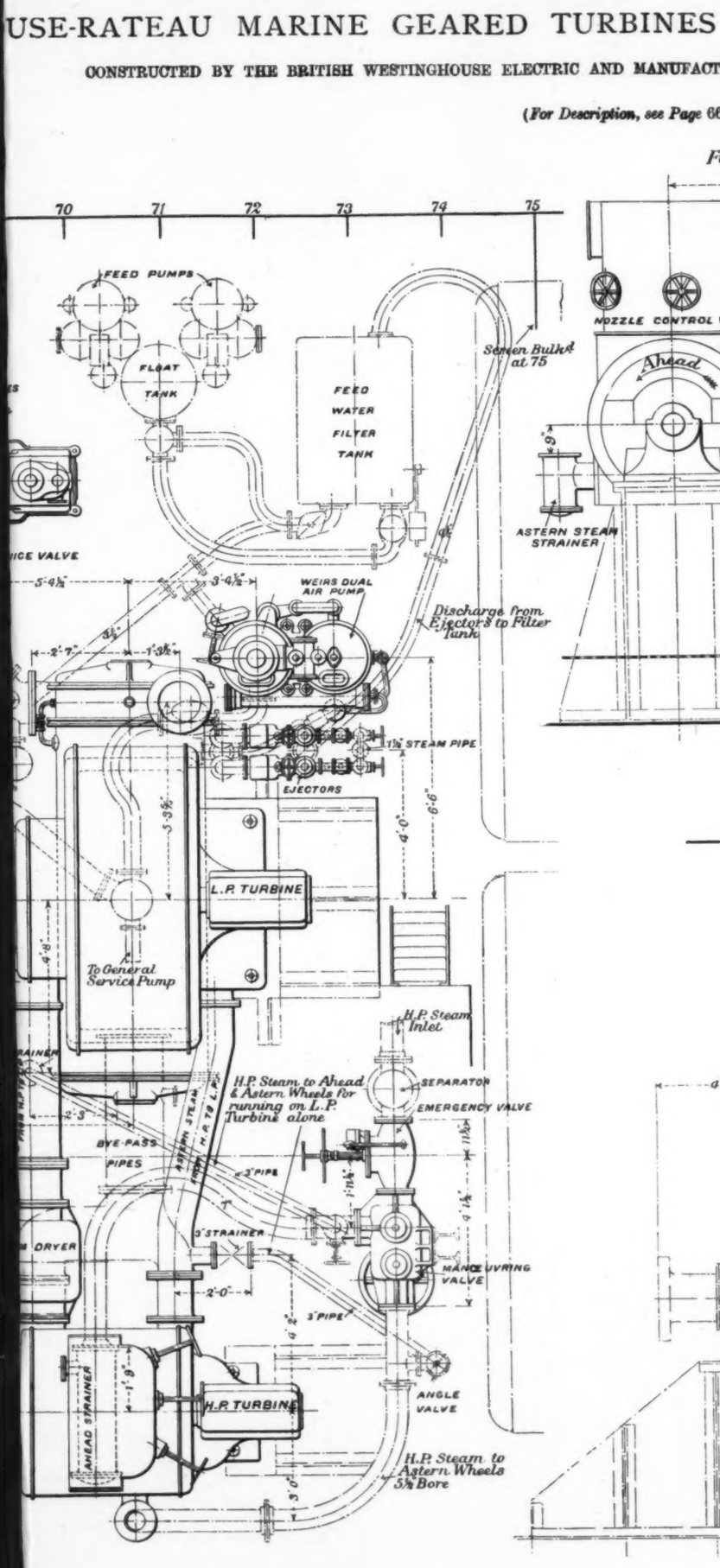


BINES FOR THE S.S. "ASSIOUT" AND "AMARNA."

MANUFACTURING COMPANY, LIMITED, ENGINEERS, MANCHESTER.

, see Page 666.)

Fig. 2 VIEW OF TURBINES LOOKING AFT.

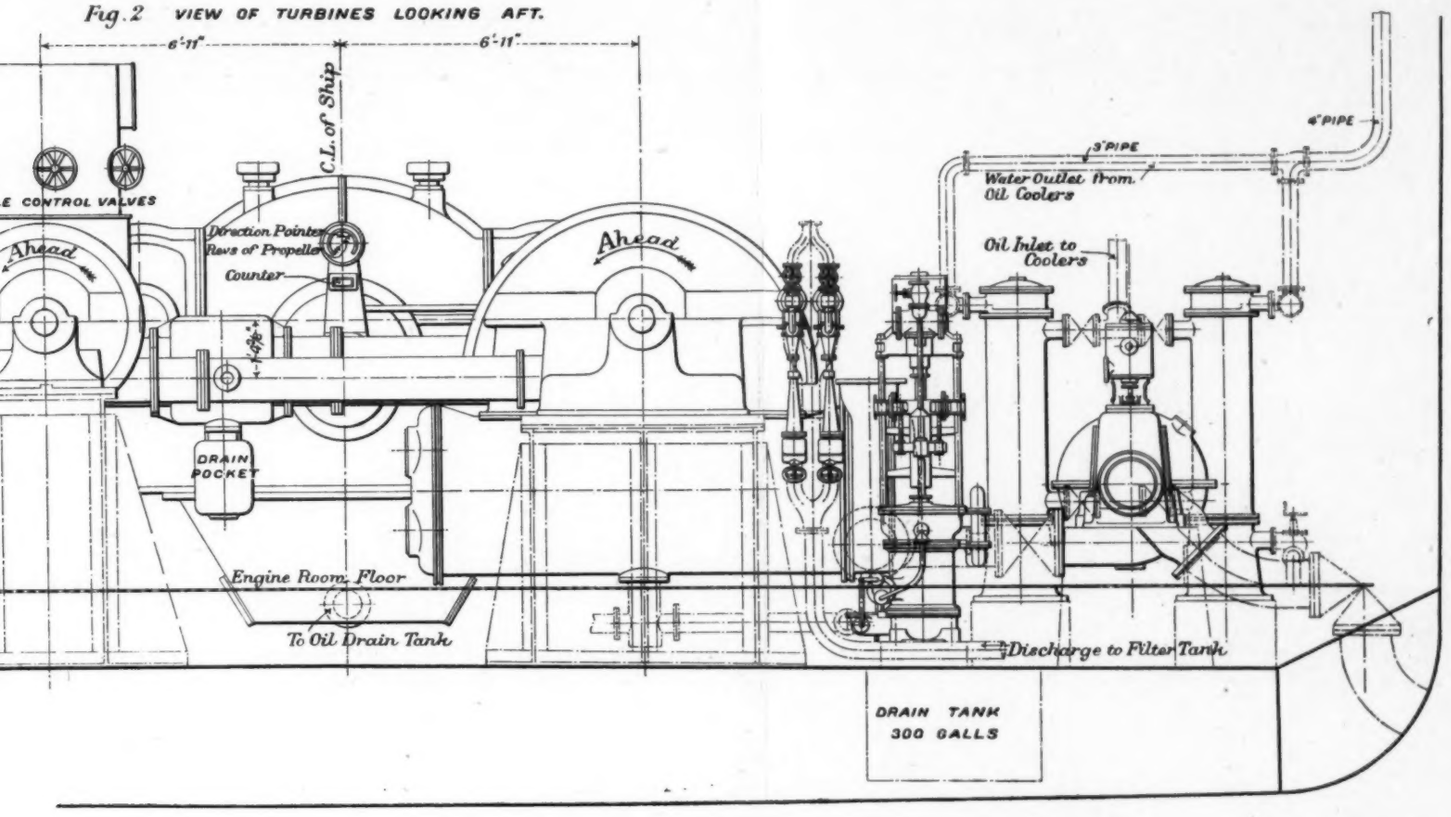
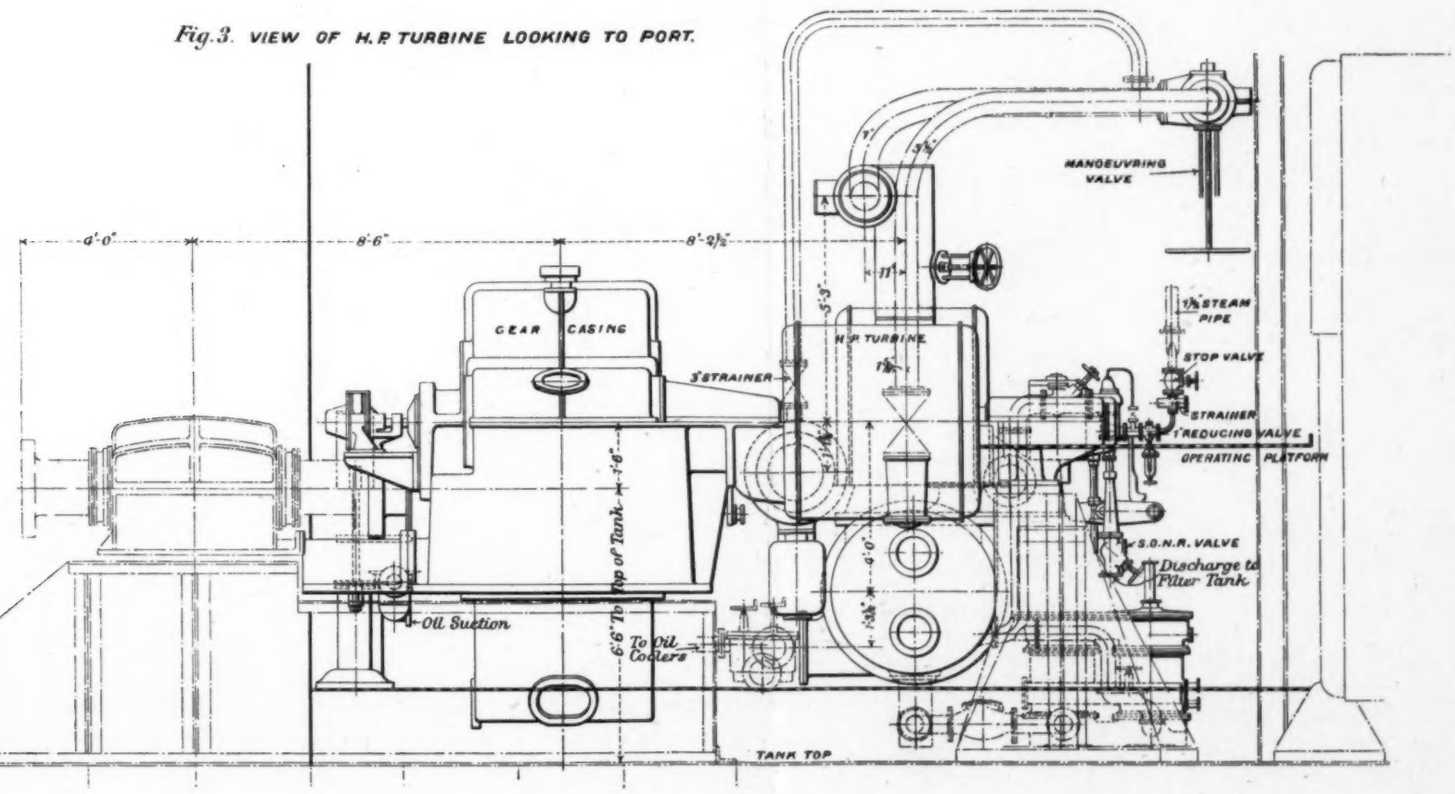


Fig. 3. VIEW OF H.P. TURBINE LOOKING TO PORT.



AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.
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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 671.

ENGINEERING.

FRIDAY, MAY 23, 1919.

RADIOACTIVITY.

RADIOACTIVITY, discovered in 1896, came of age during the war, but it was hardly owing to the war that the event passed almost unnoticed, though the war seriously interfered with radioactive researches as with all philosophical study. Radioactivity never enjoyed real popularity even in its infancy. There is too little in the radioactive phenomena to catch the popular fancy. An electroscope is discharged; a faint glow can be seen; there is a slow spontaneous generation of heat or rather of warmth, and the most striking phenomena, the scintillations visible in the spentharioscope, can only be watched by one person at the time. If the public were disappointed by radioactivity, some scientists were annoyed. To revolutionise the whole atomic theory, the bedrock of chemical science, on the strength of some peculiar and discordant observations, to preach the disintegration of the elements, to create fresh elements "living" for thousands of years or for fractions of a second, and to assert that the most violent chemical reactions are merely skin effects or outer-shell effects, not affecting the core of the atom, appeared rank heresy, unworthy of scientists.

But the band of workers in the new field swelled, order was established in the apparent chaos, radioactive phenomena were found to occur with the regularity of astronomical events, and at present radioactivity is generally accepted, though as an obscure oddity rather perhaps than as anything likely to play a part in matters technical and general. Even the Chemical Society of London—rather a conservative body, observing a dignified reserve to new theories—gave its official *placet* last December to radioactivity by inviting Professor Frederick Soddy, one of the fathers of the disintegration theory, to lecture on radioactive changes, and last Tuesday Professor Soddy delivered the May lecture on "Radioactivity" before the Institute of Metals. Meanwhile Professor Soddy—as Professor H. C. H. Carpenter remarked in introducing the lecturer—had received a call from Aberdeen to Oxford, as Lee's professor of inorganic and general chemistry. There had only been a Lee's readership so far, which Professors Vernon Harcourt and H. Brereton Barker had held in their turns, and the creation of the new chair is itself significant. For reasons which we stated above Professor Soddy had not many new facts and deductions to bring before the Institute of Metals, and he refrained from speculation; yet his lecture will remain memorable.

Although in a sense an entirely new and unique property of certain elements, radioactivity is fundamentally connected in particular with the study of the vacuum electric discharge since 1860. Professor Soddy referred in this connection especially to the radiant matter of Crookes and to the cathode and Röntgen rays (1895). In 1896 Becquerel discovered that uranium and its compounds spontaneously emit radiation of the type of X-rays producing ionisation, phosphorescence and photographic effects, and having X-ray penetrating power. The Zeeman effect and J. J. Thomson's work then made it clear that some of these radiations consist of electrons or negatively-charged units of electricity, which normally occupy the positions of satellites to the more massive material atoms and, disturbed in their orbits, give rise to radiation, but are capable of separate existence. In their systematic search for radioactive elements, the Curies, husband and wife, found only two, both of very high atomic weight, the first uranium (atomic weight 238·15) occupying the last place in the periodic table and belonging to the sixth family (closely allied to chromium, molybdenum, tungsten), and the second thorium (232) belonging to the fourth family (cerium and zirconium). Later, potassium and rubidium were observed to emit a feeble X-radiation; but Professor Soddy did not consider that these elements could be accepted as radioactive in the full sense. The minerals of both uranium and thorium were, however, found to be far more radioactive than could be accounted for by their contents of U or Th, and in due course three new elements, radium, polonium and actinium were proved to be associated with uranium. Of these only radium has really been isolated in minute quantities and found to resemble barium and bismuth; the two other new elements are only known by their specific radioactive properties which, Professor Soddy emphasised, suffice for recognition and distinction quite as well as ordinary chemical properties. There is only one part of radium to 3,000,000 parts of uranium in minerals, and as all the compounds have the radioactive properties of the metal, the latter has no particular interest.

Radium, many million times more radioactive than uranium, evolves heat at the rate of 133 gramme-calories per gramme per hour, enough to raise its own weight of water from freezing-point to boiling-point in 45 minutes, and this rate seems to be constant and only to diminish by 4 per cent. within a century, Professor Soddy stated. Of the three radium radiations, the β-rays, first studied, were stopped by 4 mm. of aluminium and were cathode rays, not of the average velocity of one-third the velocity of light, but of 99.5 per cent. of that velocity; with their aid Kaufmann had been able to demonstrate that the inertia of the electrons was purely electromagnetic. The feebler, but most penetrating γ-rays, of the nature of X-rays, were reduced to one-half their initial intensity by 1·4 cm. of lead, the law being exponentital, so that 27·5 cm. of lead would stop all but one-millionth part of this radiation. Crystal study by means of X-rays had shown that there were several series of X-rays; the K series of shortest wave-length was given by elements of low atomic weight, from sodium up to tin; the L series by elements from zinc up to uranium; the M series by elements from gold up to uranium; when an element gave several of these series, the K series had much higher frequency than the L and M series. As regards the penetrating power of the β and γ rays, the lecturer added an instructive remark. With respect to the penetration of transparent media ordinary light had no equal. For the new radiations opacity did not count; the absorption was fixed, in the first instance, by the mass of material in the path. The γ rays would be stopped by 25 cm. of mercury or by the atmospheric equivalent of 25 cm. of mercury, whilst we saw our sun through an atmospheric equivalent to 76 cm. of mercury; if the sun were made of radium, our atmosphere would completely protect us from the γ-rays. The third radiations of radium, the α-rays, carry a positive charge and totally differ in character from the β and γ rays; they are stopped by a thin sheet of paper and a few centimetres of air.

In 1900 Rutherford discovered that thorium compounds gave out α and β rays and, in addition, a radioactive substance itself emitting α rays, which diffused away like a vapour, and which he called thorium emanation. Actinium and radium were then found to give similar emanations which retained their temporary radioactive characters for a few seconds (actinium), a few minutes (thorium) and a few weeks (radium). That emanation formed a radioactive deposit on surfaces with which it came in contact, and concentrated in electric fields on the negative electrode; it could be condensed by cold and volatilised by heat like a gas and behaved as if it were one of the inert gases. It was the investigation of the thorium compounds which suggested to Rutherford and Soddy in 1902 that radioactivity consisted in the continuous production of new products as well as of characteristic radiations. Mdme. Curie, Professor Soddy stated, had

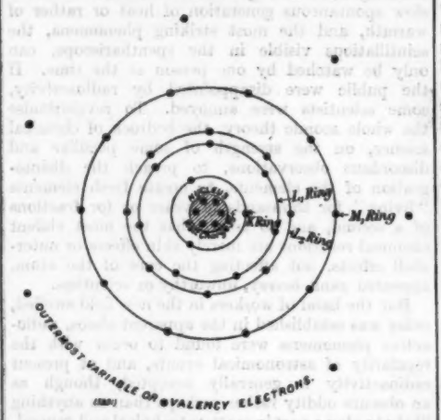
succinctly described radioactivity as an atomic property which was exhibited unchanged in all the compounds of the atom, under all conditions and incapable of being created or destroyed, and there was indeed only one other atomic property in that sense, namely mass. What Rutherford and Soddy asserted in their theory of disintegration was that the changes were transmutational rather than chemical. A radioactive substance undergoes a complex series of successive changes; each change is accompanied by the expulsion of an α-particle—one at the time—or a β-particle—also singly probably—per atom disintegrating. Radium, *e.g.*, gives first an α-particle and emanation; the emanation in its turn expels another α-particle and becomes RaA; the RaA expels a β-particle and changes into RaC which undergoes a complex change; a β-particle is expelled and immediately afterwards (at an immeasurably short interval) an α-particle follows, and that is apparently the end. But a feeble β-activity persists, and the substance passes through D into E and RaF (identical with what Mdme. Curie had christened polonium); with the final expulsion of one more α-particle this series really comes to an end.

The law of all these complex and, as long as not understood, hopelessly bewildering changes, whether slow or rapid, is that of monomolecular chemical changes. A definite fraction, λ, which may be small or large, of the total number of atoms of the radio element disintegrates per second; the average life-period is the reciprocal of the radioactive constant, $1/\lambda$. Thus *e.g.*, 1/463,000th of radium emanation breaks up per second, and the life-period is 463,000 seconds, or 5·55 days. The period of half-change is always $0{\cdot}6932/\lambda$ and remains so throughout. When the parent element is left undisturbed in a closed space, the intermediate products accumulate to a definite equilibrium proportion, the several quantities being proportional to the respective life periods. When radium emanation is allowed to accumulate in this way there will, at equilibrium after several weeks, be found 0·6 cb. mm. of emanation per gramme of radium, or 0·1356 cb. cm. per 226 grammes of radium. Since the gramme-molecule of any gas occupies 22·2 litres at normal pressure and temperature, and the molecule and atom are the same in the case of the inert gases, 0·1356 is six-millionth of the gramme-atom of emanation, the ratio of the numbers of atoms of emanation and of radium is 1 : 6,000,000, and the life period of radium is $6{,}000{,}000 \times 5{\cdot}55$ days, or 2,500 years. The rate of this change is thus 0·04 per cent. per year, and that figure is in agreement with numerous other independent determinations. On this argument rests also the only estimate so far made of the life period of uranium, $6{\cdot}4 \times 10^9$ years.

The α-particles Rutherford found to have four times the mass of hydrogen atoms, to travel with velocities up to 1/14th the velocity of light, and to carry two positive charges; Ramsay and Soddy had meanwhile identified the gas with helium by means of spectroscopic tests. In air at 15 deg. C. the fastest of these α-particles of RaC have a range of 6·94 cm., those of thorium a range of 8·6 cm. In mica or glass the range is 0·02 mm.; Ramsay and Soddy were hence able to collect the helium generated by radium emanation, confined in a glass tube of very thin walls, in the jacket of this tube.

When it had been established that helium was formed by spontaneous evolution from radium, the problem of the origin of radium from uranium was systematically attacked. If uranium directly passed into radium, that problem might easily have been solved; for one-hundred millionth of a milligram of radium emanation can be detected in the presence of kilogrammes of other substances by electroscopic tests. But the solution took seventeen years. Since 1903 and later Professor Soddy has sealed up three different specimens of uranium; in one sample of 1909 he found a few weeks ago 25×10^{-11} grms. of radium, and from these various observations he concludes that the ionium, which according to Boltwood is the immediate parent of radium, has a life period of 100,000 or 105,000 years. Thus one part in 7,000,000,000 of uranium changes into ionium per year; yet in ten years 3 kg. of uranium would accumulate an amount of radium inconveniently large for measurement. The study of the evolution of actinium (solved last year by Hahn and Meitner and by Soddy and Cranston) brought up a new feature of radioactive change. Two series of changes there proceed simultaneously, a main series and a branch series. Why are certain atoms selected to undergo these disintegrations, to die in other words, whilst others are allowed to live on?

There is no answer to this question. To the chemist, imbued with the nineteenth century idea of the atom as an ultimate particle occupying a definite position in the periodic table, the whole suggestion of disintegrating atoms was sufficiently bewildering. But the changes could not be disputed; various lines of investigations led to the same results, and with the breakdown of a single element the whole theory, as so understood, would break down. Professor Soddy has pointed out on other occasions—noticed by us—that the atomic theory does not necessarily make the atom the ultimate particle, and we have given more particulars of the complex changes involved. For the advocates of the new views the trouble was that there was no room for many of the new elements in the periodic table. There was room for radium and its emanation, probably also for polonium and actinium, but certainly not for the other crowd. But Fleck and others proved many identities, and



the generalisation independently suggested in 1914 by A. S. Russell, K. Fajans, and Soddy, helped over that difficulty. The expulsion of an α-particle shifts an element two places backward (down) in the periodic table, the expulsion of a β-particle one place forward. The new substance is an element as along as it lasts, whether for minutes or for years. If the new place be already occupied, the new substance is an isotope (something occupying the same place as another element). Various isotopes resemble thallium, bismuth, tantalum, &c.; they differ from the respective element in position totally as to radioactive character, they differ also in atomic weight, but they do not differ chemically, and may be and are inseparable from it. The main support of this startling deduction is furnished by the fact that lead, the ultimate disintegration product both of uranium and thorium, was found to have a smaller atomic weight (about 206 against 207·2, the atomic weight of ordinary lead) when derived from uranium, and a larger weight (nearly 208) when derived from thorium, in accordance with predictions. There again the independent determinations of Hönigschmid, T. W. Richards and Soddy are in accord. Ionium, which is identical with thorium in the general sense, similarly has an atomic weight approaching 230, against thorium 232·12; Hönigschmid's thorium contained apparently (radioactive tests) 30 per cent. of ionium, and that agreed with the atomic weight he found, 231·5.

The modern views on the structure of the atom, which electric and other researches have forced upon us, help us also to conceive the possibility of the radioactive changes, and the difference between transmutations and ordinary chemical change. The diagram we reproduce above was exhibited by Professor Soddy; it is due to L. Vegard—whose work on aurorae and cathode rays we have noticed—and it embodies views of J. J. Thomson, Rutherford, Bohr, Moseley, Debye, and others. This model of the bromine atom credits bromine (atomic weight 80, atomic number 35) with 35 net positive charges; as there should be 40 (80/2) positive units, some electrons are placed in the nucleus. Mass and radioactivity, according to these views, are due to the nucleus; X-rays and spectra originate in the completed inner rings of electrons; chemical and physical changes affect only the outer (not closed) ring of valency electrons. Isotopes have the same net nucleus charge, and the same external electronic system, but their nuclei are differently constituted: the nucleus practically accounts for the whole mass of the atom.

Whether or not such models of planitary atoms can stand, it is clear that radioactivity originates in the very heart of the atomic system, of which we had no previous conception, and for that reason radioactivity has no temperature coefficient and can not, so far, be accelerated or retarded in any way. The energy involved is enormous; but it is evolved at an infinitely slow rate. The complete change from uranium into lead requires millions of years. If a ton of coal contain energy worth 4 grammes of gold (half a sovereign), Professor Soddy said in concluding his address, uranium might be considered worth four times its weight in gold, and that value would be real, not conventional, as in the case of gold. It may be possible to accelerate radioactivity by bombardment at much higher electric potentials than are at present available, as Dr. Rosenhain suggested in seconding the vote of thanks to Professor Soddy. Professor Soddy was ready to grant such a possibility. He also pointed out that it was strange that we should only know of two ultimate disintegration products, the dull metal lead and the indifferent gas helium. But he did not go further. He did not even dwell on the singularly restricted number of radioactive elements. The preconception is that nothing in the universe is immutable—except human prejudice itself.

EMPIRE PATENTS.

AMONG the many proposals that have been made for amendment of the present Patent Laws, there stands that relating to an international patent covering the whole world, or a patent covering the British Empire. There are reasons for and against such patents, both from the point of view of the inventor and from that of the public, but it is generally assumed that at least some extension of the territory covered by a patent is desirable. The object of this note is to explain certain of the difficulties that may arise, and to indicate some points of importance in the granting of, say, a patent covering the British Empire.

Patents for inventions in this country are granted under the Patents and Designs Act, 1907, which is based on the Statute of Monopolies, 1623, or rather the Statute of Monopolies—which declares that all monopolies are contrary to the laws of the Realm, and are, therefore, void and of no effect—expressly excepts patents granted "for the sole working or making of any manner of new manufactures within this Realm to the true and first inventor of such manufactures, provided they were not in use by others, nor contrary to the law, nor mischievous to the State by raising prices of commodities at home or hurt of trade or generally inconvenient." Thus Letters Patent for inventions can only be granted for manufactures new in this country and not in use by others.

When we come to the Colonies, different considerations apply in some cases. Some Colonial Patents Acts are based on the British Patent Act, as, for example, is the case in India. Some are based on the United States Patent Act. This is the case, for instance, with the Union of South Africa. In this Union, in addition to it being necessary for the manufacture to be new within and outside the Union, it must not have been patented in any other country more than twelve months prior to lodging the South African patent. Again, in Canada, an inventor may obtain a patent if he has already patented the invention elsewhere, by making an application for a Canadian patent

within one year of the date of the issue of the first foreign patent.

Thus, the first point necessary will be to bring the various Patents Acts into line from the point of view of novelty, and to decide whether an Empire patent shall be considered novel provided it has been published before anywhere within the Empire, or provided it has not been published in some particular part of the Empire. That is to say, is publication of an invention in Ceylon to be a bar to the grant of valid letters patent in Great Britain? If this were so, it would lay the inventor open to attacks from many directions if his patent were tested in Court, and it would also mean that the defendant who was able to spend a considerable amount of money in searching throughout the Empire for anticipations would have a better chance of success than one who could not command the large funds necessary.

This difficulty could be overcome by providing that a patent after grant should be held to be valid, but in that case the period within which opposition could be lodged to the patent would have to be much greater than at the present time, and the grounds on which opposition would be lodged would need to be very general. On the other hand, this opposition period ought to be definitely limited, so that the patentee after that period would know exactly his position. If a patent were to be held valid after grant, then it would be necessary for a thorough search to be made before the patent was sealed. At the present time a fairly comprehensive search is made before patents are granted in this country, and this also applies to other countries, such as Canada. On the other hand, the main bulk of the colonies make no such search, and probably have no facilities for making it. It would, therefore, be necessary either to establish patent offices capable of making the searches in the various countries, or better still, to refer all applications to this country before grant, in order that a search could be made. If that were done, clearly the search would extend through Colonial patents as well as British patents, these being ultimately merged into single Empire patents, so that in the end the search would only be made through Empire patents, except as mentioned below, assuming that it be held as it is in this country at the present moment, that a patent should not be invalidated only by a printed specification published more than 50 years prior to the patent application. In addition, a search would have to be made through foreign patents and literature, because as according to the Statute of Monopolies, the manufacture must be new in this country, it must not have been disclosed in a technical book, or say, in a French specification available to the public. Such a search is made before patents are granted in the United States of America, so there is no reason to suppose it could not be made here.

There then remains the most difficult case of anticipation to deal with, namely, that of prior user, or in other words that of publication by a man who worked the process or constructed the machine of the invention at some prior time, and showed it publicly to others, but did not describe it in print.

In patent actions it often entails considerable expense to search for and find cases of prior user, and it would be increasingly difficult if in the case of an Empire patent prior user in a colony should affect the validity of such a patent after a certain time. It would, therefore, be necessary to arrange that the case of a prior user not brought forward in opposition proceedings before the grant of a patent should not be ultimately available for disputing validity.

If the Empire patent had been granted, there would be questions of renewal fees to be considered and the manner of their payment. Not much difficulty need arise on this ground, because according to the British system no fees are required for several years and after that fees are payable annually. This system could be extended to an Empire patent, the fees being paid in the Colony in which the inventor happened to reside, and a record of the fees being kept in this country.

In litigation matters, there would need to be some unifying system dealing with matters of infringement, and yet this would need to be sufficiently elastic to enable cases to be tested locally. There, again, no great difficulty need arise, and the present system could be utilised, that is to say, taking, for instance, Canada, ordinary infringement actions are tested there in the first instance, but the final appeal is by way of the Judicial Committee of the Privy Council in this country. By referring all actions ultimately to such a supreme court the necessary unity would be secured, but it would be desirable so to arrange matters that the fees were not prohibitive.

SALVAGE OF DISABLED WORKMEN.

THE Coal Industry Commissioners have found it possible to deal with a large crowd of subjects more or less interrelated. Excellent are the ingredient materials, if at times in dubious proportions and crudely seasoned. To the contribution supplied on Wednesday and Thursday, May 14 and May 15, by the medical adviser to the Ministry of Munitions we take no objection so far, at any rate, as concerns his views on the prevention of accidents, and his proposals for the salvage of injured miners. We need not consider now how far more piercing inspection of plant, roofs and roads, with weekly open notification of casualties, might augment the sense of responsibility of owners, managers and men, and as a consequence lead to a reduction in the number of accidents. Enough that the words at once convey an appeal to the common sense of even the non-expert in colliery practice.

Since accidents will continue to happen to miners, as to other industrial workers, however meticulous the supervision, we welcome Dr. Shufflebotham's clear statement of how to deal with the survivors of colliery accidents. He stated that "he knew discharged soldiers who had been injured in such a way that they required massage and electrical treatment, and he thought this treatment should be extended to the mining industry in which so many discharged men are employed." Dr. Shufflebotham aims at salvage. Obviously his reference includes instances known to him of disabled soldiers who, as a result of systematised orthopædic treatment have been able to return to their work in collieries. Here it may be remarked that evidences of the efficiency of such treatment are broadcast, and, further, that the Local War Pensions Committees and the Ministry have unassailable information of the wonders that have been achieved. Needless to say, however, the list of remarkable recoveries is not restricted to those whose pre-war occupation was coal-mining. So we may take it that the evidence and arguments of this witness in support of providing special orthopædic treatment for miners, whether injured in the war or at their work, applies equally well to other injured industrial workers. Doubtless the largeness of the number of colliers, say 1,000,000, and the national need for their underground labour, may seem to justify the advocacy of specific legislation in their interests, and of an attention to the problems of their health maintenance and bodily repair, considerably in advance of that which, as the witness declares, has hitherto been given by the Home Secretary.

Here is Dr. Shufflebotham's formal recommendation to the Commission: "That means be taken to ensure the best possible after-treatment for miners who sustain injuries or contract diseases which are directly due to their employment in the mines." Quite a moderate proposition, and one with which we are in sympathy. But the scope is narrow, dangerously narrow, for the arrangements touched upon by the witness must be extended to the whole body of our industrial workers if we would have the man-power of the nation a maximum. It is true, as the doctor declared in his reply to the Chairman, that sufficient provision for repair of injured miners during their convalescence had not been made by local enterprise or in other ways, and it followed naturally that he should urge for each mining district the institution of an orthopædic clinic on the lines of those that had been created here and there for disabled soldiers and pensioners. So far we are in agreement, but, we hesitate to accept the further recommendation that there should be built up under a Ministry of Mines a brand new and complete medical service for colliers alone with full opportunities and responsibilities for this distinct professional corps. There may be something to say for organising the trade of coal-mining on a quasi-army footing, and, therefore, the creation of a mining-medical service which would carry out recommendations for after-treatment of injuries, but there is much more to say for the stirring-up of an effective desire to apply the wonderful methods and equipments of orthopædic hospitals to cases of disablement from the wide range of accidents in any of the industries on which our general and individual prosperity depends.

Although operational and reparative experiences come in full flood to our war surgeons, and although the record of achievements in restoration during the past four years are great beyond all anticipation, it must not be forgotten that the principles, and in some measure, the processes which give distinction to orthopædic hospitals are not new. The essential ideas had been formulated with precision long ago, and institutions with well-ordered programmes of treatment had been at work. Even the economic importance of such treatment for industrial progress had received earnest attention. A biennial International Congress of surgical experts and specialists from all the civilised countries of the world had begun to meet, for a week at a time, with the object of interchanging opinions and discussing experiences relative to the various forms of industrial accidents. Their objective was not so much the healing of wounds as the restoring, in minimum time, of dexterity and power of work. The outbreak of war cancelled the meeting which should have taken place in Paris in August, 1914. The previous meeting was held in Dusseldorf in 1912. Among the British representatives taking part in the work of that Congress were Dr. Shufflebotham, whose valuable evidence and recommendation relative to mining accidents prompted this article, and Dr. Kerr, of St. Helen's, whose detailed and illustrated account of a highly organised and splendidly equipped modern institution—the Pilkington Orthopædic Hospital—appeared in our issue of January 3, of this year. It was at the Dusseldorf congress that Dr. Kerr insisted on the necessity of having operations determined by the possible future functioning of the injured part, and on the importance of employing re-educative influence as soon as is surgically possible. The article to which we refer gives a clear view of what orthopædic surgery means, what it has done and what part it must continue to play in maintaining our industrial man-power at its highest productive efficiency. The salvage of disabled workers makes for the protection of the State.

RAILWAY WORKING DURING THE WAR.

THE publication of the statement showing the cost of running the railways in Great Britain during the period of Government control (1914-1918) has already given rise to some plain speaking in the Press, and we are quite sure that the matter has by no means been disposed of. For some extraordinary reason there has been during the war a conspiracy of silence as to the financial result of the taking over of the railways by the Government. There have been many estimates and general statements, but no facts. In the light of the figures now given it will be seen that some of the statements can only be described as incorrect; indeed, we are tempted to think that facts have been deliberately concealed. In our issue of January 3rd, 1919, we referred to the statement by Sir Albert Stanley in the House of Commons on May 15th, 1918, in which he said that "A careful calculation to-day and since the last increase to employees' wages was made will disclose that the bargain will show a loss to the State." In the same statement the President of the Board of Trade directed attention to the estimated increase in the wages bill, the fact that railway goods rates had not been advanced, the economies effected, etc., but gave nothing that could be described as in the

nature of accounts or statistics. We may be pardoned for repeating the comments we made at the time. We said:—

"If this is the kind of information that is to be placed before the House of Commons to enable it to form a sound judgment as to the railway problem, it will be for someone to speak out very plainly. As Sir J. Bethell subsequently said: Most people were under the impression, having regard to the heavy traffic, that the railways were making a profit. He would have liked to see a statement showing the income and expenditure for last year and the losses incurred. That is the point, and it must be met. In our last issue we gave statistics of the pre-war railway traffic, including the number of passengers carried and the weight of goods and minerals conveyed. Sir Albert Stanley has asserted that, exclusive of Government traffic, those totals have been exceeded. Now, there is no possible reason why the Government should not publish the total receipts of the railways for traffic other than that carried free on Government account. The figures are known to the Board of Trade, as without them the amount of compensation payable by the Government cannot be determined. We may recall that, to ascertain the compensation payable, the aggregate net receipts of all the railways taken over by the State is compared with a similar aggregate for the corresponding period of the year 1913. The ascertained deficiency is the amount of compensation due. It need not be said that, before the net receipts can be ascertained, the gross receipts and gross expenditure must also be computed. Therefore, the Government know (1) the total railway receipts, (2) the total railway expenditure, (3) the total net receipts, and (4) the amount that has been paid in order to make up the deficiency as compared with the year 1913. That information must be disclosed in order to show the basis of Sir Albert Stanley's statement in regard to record railway carryings. To anticipate an inquiry why individual railways have not published the facts in regard to their respective systems, we may say that they do not know. When the railways were taken over by the State and the agreement regulating compensation had been made, it was unnecessary to do what is technically known as 'divide' the traffic. Each company accounts for the money it actually takes. If the balance exceeds its net receipts for the year 1913, the surplus is paid to the Railway Executive Committee, and is used in payment of the compensation to the companies whose net receipts are less than for the year 1913. Division of traffic receipts in pre-war days was made by the Railway Clearing House, and its abolition has necessarily effected much economy. The result, however, is that no one company knows how it really stands financially. It may be conveying more traffic, but it does not know accurately how much would be its correct proportion of the receipts. This is known only in respect of all the railways when the receipts and expenditure of all the companies are thrown together in the manner already described."

Now that the figures have been published, the correctness of our statement will be apparent. The Board of Trade could have given accurate figures at any time, and they must surely have known that they would show that the Government had made a profit, and that the railways were by no means bankrupt, as had been alleged, more especially as no increase has yet been made in rates for the conveyance of merchandise and mineral traffic. The statement of revenue earned and expenditure of the controlled railways in respect of working for the year 1913 and for the period of Government control to December 31st, 1918, is shown by the table annexed.

The figures speak for themselves, but even they do not go far enough. We feel that more light is needed in regard to two items. As regards the estimated value of Government traffic, we should like to know exactly what traffic is included in the estimate. In a covering memorandum by Sir Auckland Geddes it is stated that the figures are in respect of rail transit only, and that the railway companies have performed a number of additional services by means of steamboats, docks, canals, &c., for which no charges have been raised. The value of these cannot be ascertained, but may be estimated at roughly £10,000,000 to £15,000,000. Apart from these additional services, we should like to know whether adequate allowance has been made for the enormous amount of free and reduced fare railway travel that has been afforded Government Departments. Practically every Department has enjoyed the right of issuing vouchers which amount to free passes over the railways, while almost anybody who could claim to be associated with the war or war service has been able to travel at reduced fare. We think that the Government should specify in detail what services are included under the heading of Government traffic, and how the figures have been arrived at.

As to the other side of the account, we must again refer to the statement by Sir Auckland Geddes, who seems to be anxious to "back up" his brother.

	Year 1913.	Period of Government Control. Period Aug. 5 to Dec. 31, 1914.	Year 1915.	Year 1916.	Year 1917.	Year 1918.
	£	£	£	£	£	£
Receipts.						
Passenger train traffic	54,096,074	19,091,103	52,576,836	54,953,831	59,710,183	69,819,265
Goods train traffic	68,551,503	26,861,560	71,754,353	74,809,050	74,310,568	72,396,409
Estimated amounts which would have been received for Government traffic if charged for at pre-war authorised rates	—	3,500,000	10,279,104	20,649,126	35,698,554	41,917,024
Total	122,647,577	49,452,663	134,610,293	150,412,007	169,719,305	184,132,698
Less—Expenses of collection and delivery	5,092,670	1,950,817	5,341,872	5,711,354	6,571,736	7,845,927
Total traffic revenue earned	117,554,907	47,501,846	129,268,421	144,701,253	163,147,569	176,286,771
Mileage, demurrage and wagon hire	150,679	1,719	9,844	9,115	4,958	—
Miscellaneous	995,349	414,623	1,079,779	1,160,717	1,126,903	1,297,550
Total revenue earned	118,700,935	47,918,188	130,358,044	145,871,085	164,279,430	177,584,321
Expenditure.						
Maintenance and renewal of way and works	11,818,310	4,623,713	11,598,234	11,924,459	13,265,610	16,145,166
Maintenance and renewal of way and works—Arrears to be carried out	—	800,264	2,984,757	5,055,609	6,282,179	6,485,228
Maintenance and renewal of rolling stock	13,257,617	5,493,599	13,741,171	15,211,621	17,620,905	21,888,238
Maintenance and renewal of rolling stock—Arrears to be carried out	—	315,446	2,476,753	3,202,694	3,667,993	3,327,049
Locomotive running expenses	17,130,661	6,918,659	19,195,992	22,604,085	24,742,848	29,973,666
Traffic expenses	23,260,765	9,405,579	24,739,143	27,397,967	32,772,823	41,621,685
General charges	2,598,209	1,094,918	2,635,550	2,692,066	2,885,972	3,140,849
Law charges and parliamentary expenses	226,346	89,039	197,250	186,802	176,517	185,812
Compensation (accidents and losses)	1,158,451	293,760	1,176,858	1,250,914	1,275,191	1,456,430
Rates, taxes, &c.	4,705,264	2,077,111	5,064,047	4,839,699	4,880,778	5,273,155
Government duty	284,361	81,101	255,341	293,174	—	—
Payments under National Insurance Act, 1911	398,870	155,192	363,652	354,126	362,339	355,496
Running powers	108,699	811	3,274	3,806	1,209	1,665
Mileage, demurrage and wagon hire	239,916	28,126	51,136	45,961	63,942	165,745
Miscellaneous	157,139	74,722	190,639	207,596	252,789	340,392
Allowance to dependants of men serving with His Majesty's Forces	—	141,683	333,225	477,425	623,395	711,009
Watching, patrolling, &c.	—	190,731	21,240	8,702	5,800	7,127
Payments to staff—Armistice Day	—	—	—	—	—	250,913
Total expenditure	75,127,210	31,782,832	85,028,262	95,756,706	108,877,932	131,326,295
Balance of revenue earned over expenditure	43,573,725	16,135,356	45,329,782	50,114,379	55,401 498	46,258,026

He states:—"The figures of £90,000,000 to £100,000,000 were quoted by the Minister-Designate in moving the second reading of the Ministry of Ways and Communications Bill. These figures were the best estimate then available of the increased cost of working during the two years of extended Government guarantee, as compared with the cost of 1913:—

"The following is the present estimate of increased cost in working the railways during the financial year ending March 31st, 1920, as compared with 1913:—

	£
War wage and other concessions	57,000,000
Eight-hour day and new concessions recently granted or still under discussion	20,000,000 to 25,000,000
Extra cost of materials and coal	27,000,000
Total	104,000,000 to 109,000,000

We are very little concerned in regard to either Sir Eric Geddes' £100,000,000 or Mr. Austen Chamberlain's £60,000,000, both of which have been taken to mean that in the year now current there would be a loss of one or other of those amounts in working the railways. But obviously in the figures now quoted by Sir Auckland Geddes two of the items, viz., war wages and the extra cost of materials and coal as compared with the year 1913, have already appeared in the accounts, and are responsible for the enormous growth in the cost of railway working. They cannot represent any material addition so far as the current year is concerned, and must not be allowed to confuse the issue. For our part, we are content to await the publication of a certified statement of accounts for the year 1919. We may, however, refer to the item of war wages. We understand that lads of eighteen years of age are now being paid 33s. a week war wages, and that they are earning anything up to £3 per week or more. We believe that even the representatives of labour do not contemplate the continuance of such a state of affairs, seeing that at a time when lads are serving their apprenticeship the value of their services cannot be placed at such an amount. Much was heard last year of the sliding scale which was agreed to by the Board of Trade with the trade unions for regulating railwaymen's war wages. Are we now to understand from Sir Auckland Geddes' statement that this scale has been permanently thrown over?

The publication of the statement is a step in the right direction, but only a step. Much more information will be required, and representatives of the business community, particularly those in the House of Commons, will need to be on the alert to see that before the country is plunged into nationalisation of railways or a control indistinguishable in effect from nationalisation, the true state of affairs is known. For our part, we are so suspicious of the increase of bureaucracy and the "dead hand" which it represents that we believe the facts have only to be made known to ensure that the community generally will share our views. Meanwhile, we think it unfortunate that certain sections of the Press should have seized upon the publication of the White Paper to attack either the railway companies or the Railway Executive Committee. The real delinquents in the suppression of information are the Government, and more particularly the Board of Trade.

WAR SHIPPING AND THE DISPOSAL OF THE NATIONAL YARDS.

ON Monday last the Parliamentary Secretary to the Ministry of Shipping, Colonel Leslie Wilson, gave the House in Committee some interesting figures with regard to the part played by the British Mercantile Marine in the war. It will be remembered that during 1917 the whole of the British mercantile tonnage was brought under the control

of a Minister of Shipping, and that a large amount of neutral tonnage, which had been kept idle by the intensified submarine warfare was gradually brought back into service. Immediately before the war the total steam mercantile tonnage of the world, including all ocean-going vessels of over 500 gross tons, amounted to roughly 40,000,000, of which 18,500,000 tons were British owned. By January, 1917, the British tonnage had been reduced by war and other losses to 17,750,000 tons, but during the whole of 1917 our net loss of tonnage, after allowing for all new construction and purchases, amounted to 2,500,000 tons. The total British tonnage at the commencement of 1918 was thus only 15,250,000, and at the time of the armistice the figure stood at just over 15,000,000 tons. The actual position early in 1918 was really worse than is apparent from the above figures, since, on January 1 of that year about 1,000,000 tons were undergoing repairs. Of the depleted tonnage available in 1918 1,850,000 tons were required for military service in connection with the transport of troops and stores, and a further 2,000,000 tons were employed for naval service as Fleet auxiliaries, armed merchant cruisers, colliers, &c.; the merchant cruisers were, however, largely used for carrying cargoes in the North Atlantic trade. In the spring of that year, owing to the German offensive in France, it became necessary to send large reinforcements across the Channel, and at the same time the greatest possible number of American troops had to be brought across the Atlantic. Between March 31 and August 31 124 extra ships were put on to the Atlantic route, and an average of 140,000 American troops per month were carried during the period. This meant a reduction in imports to the United Kingdom of some 300,000 tons per month, and totalled to about 2,000,000 tons over the period during which the Atlantic transport work was being carried on. This country had also to provide for the needs of our Allies, and during 1918 over 1,000,000 tons of British shipping were used in the service of France and about 750,000 tons in work for Italy. Since January, 1917, when the Ministry was formed, 13,000,000 effective troops and 39,000,000 tons of stores were carried.

That the tonnage available was efficiently employed can be shown by comparing the imports during the existence of the Ministry, which included the most difficult period of the war, with those for the year 1913. In that year the imports brought to this country in British ships amounted to 35,000,000 tons and the tonnage of ships employed was 12,000,000. In 1917, although the tonnage available was only 7,500,000, the imports only fell to 31,000,000 tons, and in 1918, when the tonnage available had been further reduced to 6,500,000, the imports still reached 30,000,000 tons. Colonel Wilson attributes this very satisfactory result to the allocation of tonnage to the most suitable services, to improved methods of loading, and to the concentration of shipping on the shorter routes. At the same time he fully realised that the results could not have been achieved but for the devotion of the British seamen, of whom 14,700 lost their lives.

Another point of considerable interest dealt with in Colonel Wilson's speech was the disposal of the National Shipbuilding Yards at Chepstow and Beachley. These yards, which had cost over 4,000,000*l.* and had not yet completed any ships, had, he said, been offered to labour organisations, which had been given an opportunity to acquire the yards or to take a share in their management either on a basis of co-operation or co-partnership. Representatives of the Labour Co-operation Union, the Co-operative Wholesale Society, the trades unions, the Parliamentary Committee of the Trades Unions Congress, and other bodies, had been interviewed, and the Government's terms for transfer, and suggestions for working on a co-partnership basis, had been communicated to them. At first the proposals had not been received with enthusiasm, but afterwards representatives of the Federation of Engineering and Shipbuilding Trades had agreed to submit the scheme to their executive. Colonel Wilson understood that the latter approved of the idea, and had undertaken to submit the draft proposals to the annual meeting, which was held at Cardiff last week. It is understood that the proposals have been rejected, which would be very regrettable as the scheme, in Captain Wilson's view, appeared to offer all the advantages that might be claimed for public ownership and to avoid the drawbacks usually attributed to bureaucratic control. The Ministry, shipowners, and shipbuilders, he added, were all prepared to give every assistance in their power to make the scheme a success. The door was not yet closed to negotiations, but, in the meantime, offers from any quarter would be considered so as to dispose of the yards to the best advantage of the taxpayers of the country.

Put as briefly as possible, the terms on which the yards were to be sold to the unions were that the purchase price was to be the commercial value of the yards at the present time, and would be the same as would be charged to any private firm or individual who wished to acquire them. The purchase price was to be paid by instalments arranged to suit the unions, the balance being secured by second mortgage debentures at a rate of interest to be agreed upon. The company to be formed might borrow money from outside sources to carry on the business, such sums being secured by first mortgage debentures. If preferred the Government would undertake to hand over the yards in a condition ready to be worked on a commercial basis, adding the cost of any additional work on the yards to the purchase price as fixed by the first proposal. The power house at Beachley would be excepted from the transaction, subject to suitable arrangements being made for the supply of power. The only other condition mentioned was that the unions should undertake that the rates of pay and conditions of labour should be the same as those prevailing from time to time for constructional work in the North-East Coast district. This proviso had been made for the reason that shipbuilding on the Bristol Channel had hitherto been unsuccessful owing to the fact that the rates of wages in this area had been the same as those paid in repairing yards, and no scheme could be successful if called upon to pay for constructional work at the same rate as for repairs.

To us the terms, although vaguely expressed, seem by no means difficult to comply with, and to err, if anything, on the side of generosity. Apparently the unions prefer nationalisation to private ownership, even when they themselves are the owners. Labour members suggested in the debate that private manufacturers would not give the same facilities for the supply of materials to the union yards as to private shipbuilding firms, but we certainly think that labour is sufficiently powerful to deal with such a position should it ever arise, which, in our opinion, is extremely doubtful. Whatever the real reason for the present position may be, if the unions adhere to their decision, an exceptional opportunity for a most interesting and valuable experiment in industrial economics will have been lost.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (*Manchester Centre*).—At the invitation of Mr. Geo. Hughes the members of this Institution will visit the locomotive works of the Lancashire and Yorkshire Railway at Horwich on Wednesday, June 4. Members will travel from Manchester (Victoria) by special train leaving Victoria at 1 p.m., returning from Horwich at 5 p.m. After the visit to the works tea and light refreshments will be provided at the Railway Mechanics' Institute. It is important that all members intending to be present should advise the Secretary as early as possible.

WATER-SUPPLY WORKS, MONTEVIDEO, URUGUAY.—The *Diario Oficial*, Montevideo, publishes a Decree authorising the Executive Power to arrange for the carrying out of water supply and sewerage works (or water supply works only) in the towns of San José, Fray Bentos, Rocha, Canelones, Maldonado, Artigas, Melo, Colonia, Tacuarembó, Durazuo, Minas, Trinidad, Florida, Rivera, and Treinta y Tres. The works may be contracted for by single cities, or groups of cities, as may be convenient, after calls for tenders, open to both nationals and foreigners. The Executive Power may also undertake the work itself, paying the actual cost in cash plus a commission to the contractors of not more than 10 per cent. of the cost of the labour and 3 per cent. of the value of imported materials. To pay for the above works the Executive Power, irrespective of the method of contracting for same, will issue Sanitation Bonds bearing 6 per cent. per annum interest, and 1 per cent. amortisation (accumulative). The remaining Articles of the Decree deal with the collection of taxes, &c., in Uruguay to pay for these public works.

THE LATE MR. WILLIAM BOYD, WALLSEND.

Many will learn with regret of the death, at his residence, Benton House, Cheltenham, on the 19th inst., of Mr. William Boyd, who was so long associated with marine engineering in the North-East Coast district, and identified from its establishment with the Wallsend Slipway and Engineering Works. He was 79 years of age, having been born at Arncliffe in 1839, eldest son of the Rev. William Boyd, Vicar of Arncliffe, Yorkshire, and Archdeacon of Craven. He was educated at Rugby School, and subsequently was a student at King's College, London, where he made a special study of the applied sciences. Later he served an apprenticeship as an engineer with Messrs. Sharp, Stewart and Co., of the Atlas Works, Manchester.

In 1863 he began his association with North-East Coast engineering, joining the engineering firm of Messrs. W. and C. Thompson as partner, the name of the firm becoming Thompson, Boyd and Co. This partnership was dissolved in 1874, when Mr. Boyd joined the board of the newly-formed Wallsend Slipway and Engineering Company, Ltd., as managing-director. Although he relinquished much of the work to Mr. Andrew Laing on the latter joining the firm in 1896, when there began great developments, Mr. Boyd continued his connection with the company for many years, lately taking up his residence at Cheltenham. In 1877, in conjunction with Mr. Manuel, Mr. Boyd carried out important experiments with steel plates as a material for boiler construction, the result of which experiments formed the basis on which Lloyd's Registry framed their regulations for the reconstruction of steel boilers. Mr. Boyd was for eight years a valuable member of Lloyd's Technical Committee. He was also closely identified with the development of the use of oil as fuel in steamships, and was co-patentee with Sir J. F. Flannery, Bart., for a system of settling tanks in connection with oil burning, and also for a patent burner for spraying oil into the furnaces, both of which patents have been and are still extensively used.

Mr. Boyd took a great interest in the proceedings of the various engineering societies, of the more notable of which he was a member, and before several of which he read papers on engineering subjects. He was largely responsible for the formation of the North-East Coast Institution of Engineers and Shipbuilders, and was elected its first President in 1884. He was also a member of various committees of the employers' associations, and was instrumental in establishing a fund known to-day as the Dyer Memorial Fund, which was raised as a tribute to the work accomplished as Chairman of the Employers' Federation by the late Colonel H. C. S. Dyer.

In the midst of a busy life Mr. Boyd always found time to discharge his duties as a citizen. In 1871 he was elected a member of the first School Board of Newcastle-upon-Tyne, of which he remained a member for six years. Soon after taking up the management of the Wallsend company in 1874 he was elected a member of the then Wallsend Local Board, of which he became chairman in 1879, an office which he held until the absorption of the old Local Board into the new Urban District Council in December, 1894, when he was returned by a large majority, and in January, 1895, was elected chairman of the new District Council. He was mainly instrumental in obtaining for Wallsend its Charter of Incorporation, which was granted to the town in 1901, when Mr. Boyd was elected an alderman and chosen as the first mayor of the borough. In recognition of his valuable services the Honorary Freedom of the borough was conferred upon him in 1907. Mr. Boyd retained his connection with the local government of Wallsend until 1907, when he resigned his aldermanship upon his removal from the district. Mr. Boyd was a Justice of the Peace for the county of Northumberland. He was also an enthusiastic Volunteer, commencing as a private in 1860 in a Manchester Artillery Corps. In 1863 he joined the 1st Newcastle Artillery Volunteers as a lieutenant, and succeeded to the command of this regiment in 1871, continuing until 1879, when ill-health compelled him to retire. Mr. Boyd was married in 1865 to Diana, daughter of the late Edward Hawks, of Douglas, Isle of Man. His wife died in 1917, but two daughters survive—Mrs. Kennedy Shaw and Mrs. Blathwayt.

MANGANESE ORE DEPOSITS IN CUBA.—In the spring of 1918, A. Burch and E. Burchard investigated the manganese-acid chrome ore deposits of Cuba on behalf of the United States Geological Survey, and the Bureau of Mines. (American Institute of Mining Engineers, March, 1919.) Manganese occurs in three provinces of Cuba, in commercial quantities, however, only in the Oriente Province, chiefly near Santiago. During the thirty years, 1888 to 1918, Cuba has mined 430,500 long tons of manganese ore, at an average value of 14·95 dols. per ton; 82,974 tons, valued at 33·18 dols. per ton, were imported into the United States from Cuba during 1918, the figure being kept low partly by transport difficulties and the cessation of hostilities in November, 1918.

INDUSTRIAL NOTES.

AN article in the *Labour Gazette* says that the general state of employment at the end of April was substantially the same as a month earlier. There was still a large amount of transitional unemployment consequent upon the cessation of war conditions. In the cotton, linen, jute and the textile bleaching, dyeing, calico printing and finishing trades employment was bad generally, and the building trade continued slack, except for maintenance and repairs. In most of the other trades, however, employment was fairly good or good for workpeople belonging to the trade.

The total number of unemployed persons at May 2, according to the donation records, was 1,093,400, as compared with 1,060,245 on March 28—an increase of 33,155. The total of 1,093,400 was made up of 402,151 men and 1,316 women demobilised from H.M. Forces, and 689,933 civilians. Of the latter 452,132 were women and girls. An analysis of 1,082,759 of the policies lodged at May 2 revealed that 63,930 of the unemployed persons were in receipt of the reduced donation which is paid to civilians after the expiry of the first period of 13 weeks' unemployment; of this number nearly two-thirds were women.

The number of men on the live registers of the Employment Exchanges at May 9 was 653,270, or an increase of 87,902 on March 28, and the number of women was 450,155, or a decrease of 113,035 on the total at March 28. The number of vacancies unfilled on May 9 was 44,211 for men and 62,369 for women, the corresponding figures for March 28 being 46,591 and 65,145.

Trade Unions with a net membership of 1,202,793, excluding those serving with the Forces, reported 2·7 per cent. of their members as unemployed at the end of April, as compared with 2·9 per cent. at the end of March and 0·9 per cent. a year ago.

Increases in wages which came into operation in April affected nearly 1,300,000 workpeople (including about 1,000,000 coal miners), while about 400,000 workpeople benefited by reductions in hours of labour. Retail prices showed a further decline, with the result that the general index number of retail prices of food and other items entering into the cost of living decreased from about 110 per cent. to 105 per cent. above the pre-war level.

At the sitting of the Coal Commission held on Wednesday, the 14th inst., Mr. H. F. Plumptre said the tract of land he had leased in Kent had an area of 3,385 acres. One portion, covering 1,062 acres, was leased for sixty years at a dead rent of 200*l.* for the first year. 400*l.* for the second year, and in subsequent years 1,500*l.* per year. The rent of the second portion, 2,323 acres, was 400*l.* for the first and second years, and for the rest of the term 3,000*l.* per year. Both leases contained a clause according to which the lessees could recoup short workings during their term, the royalty in each case being at the rate of 35*l.* per foot per acre, or approximately 6*d.* per ton. Soon after the beginning of the war, the lessees asked him that he should forego all his minimum rents during the war and for six months after. He expressed his willingness to grant this upon terms which had since been fulfilled, with the exception of one, namely, that no colliery or works were to be put down within certain limits of Godnestone House.

Mr. E. O. Forster Brown stated that in the event of nationalisation, the companies which had done pioneer work would have to be compensated and remunerated, and the knowledge acquired and the development carried out by them would have to be handed over by them to the State. It was improbable that the State would be in as good a position to benefit by the experience obtained by the individual companies as the latter companies themselves. The Kent coalfield had, at present, an output of 3,000 tons per annum; the developments had now been suspended, partly owing to the uncertainty as to whether the mines were to be nationalised or not, and partly in view of the recent recommendations of the Coal Commission which made it uncertain whether it would be worth while developing this field on the basis of these recommendations. He thought that the natural conditions of the Kent coalfield now known were such that it was justifiable to estimate that an output of 10,000,000 tons per annum could be developed and maintained within seven years time, subject to adequate inducements being provided for the necessary expenditure to enable this output to be obtained.

Mr. H. E. Mitton gave instances in which exploration for coal was stopped since the appointment of the Commission, adding that it was greatly to be deplored that work of this character had now been arrested practically over the whole country, at the moment when the nation had before it the enormous task of re-starting industry.

Sir Malcolm Delevingne, Assistant Secretary, Home Office, gave evidence as to safety and health in the collieries, and said that on the whole the Home Office system of regulation had worked well; the accident rates had steadily diminished, and a very high standard of management generally had been obtained. Accidents due to breach of regulations were a small proportion of the whole. He was very uncertain whether nationalisation would result in any appreciable reduction in accidents.

Dr. J. S. Haldane, F.R.S., Oxford, said coal-mining in this country entailed less loss of life than average occupations. The accident death rate among coal-miners had diminished to about one-quarter of what it was sixty years ago. This was due partly to the better wages earned, partly to improved methods of mining, and partly to greater knowledge and skill, better discipline and greater loyalty to one another of those engaged in the industry. It was most emphatically not his experience that in the conduct of the industry, whether on the part of the managers or the manual workers, motives of gain interfered with regard to the safety and health of fellow men. As to nationalisation, he shared the general British distrust of too much bureaucratic control, and he thought that as far as health and safety were concerned, it would hardly be possible to nationalise coal-mining without largely stifling initiative and the sense of individual responsibility. In the matter of bad housing, Dr. Haldane was disappointed to find, when he considered their apparent earnings, that a very intelligent class of persons should acquiesce in living amid overcrowding and discomfort of every kind. They said that they objected to paying more than 2*s.* per week for a house; it did not seem possible to provide proper housing at such a rent.

Mr. F. Shufflebotham, medical adviser to the Ministry of Munitions, said his impression was that working miners were a healthy set of men. He recommended, among other points, that provision be made for reducing the temperature of hot seams in the coal-mines, and that the increase in candle-power of the miners' lamps be increased without delay.

At the sitting of Thursday, the 15th inst., Mr. C. H. Mertz said this country had not done what it could to develop scientifically the best means of utilising its coal resources, apart altogether from the getting of coal. Nearly 17,000,000 tons of coal were used in 1913 as fuel at the collieries, whilst the power produced thereby could have been obtained in a large modern station with one-fifth of this quantity.

In the course of the following sitting, held on Friday last, Mr. W. Walker, Acting Chief Inspector of Mines, stated that the death rate in British coal-mines did not compare unfavourably with similar mines in the colonies and in foreign countries. The conditions under which the British mines were being worked were more dangerous than they had been hitherto, owing to increased depth and to the seams producing greater quantities of firedamp and coal dust in some areas. The suggestions that there should be a committee of management at each pit, with executive power to interfere with the manager would not result in increased safety. The following figures, for the year 1912, give respectively (*a*) the number of persons employed under and above ground at coal-mines; (*b*) the output in tons; (*c*) the deaths from accidents; (*d*) the death rate from accidents per 1,000 persons employed; and (*e*) per 1,000,000 tons:—

	a.	*b.*	*c.*	*d.*	*e.*
Great Britain and Ireland	1,072,393	264,595,395	1,258	1·17	4·75
United States	732,662	484,864,900	2,442	3·26	5·04
Germany ..	718,673	255,880,100	1,750	2·44	6·84
France ..	202,385	41,145,180	302	1·49	7·34
India	132,567	14,942,340	159	1·20	10·64

Other witnesses dealt with the provision of baths at the collieries, and confirmed the figures given by Mr. Mertz of the coal consumed at collieries and possible saving by the use of current.

Sir C. G. Wade, Agent-General for New South Wales, emphasised the fact that State ownership did not stop strikes, and Mr. T. J. Callaghan, Cardiff, expressed the opinion that if there were any industry which should not be nationalised it was the coal industry which, especially in South Wales, depended upon an export trade. During the war the American coal output had increased by 115,000,000 tons, whilst the British had decreased by 60,000,000 tons. The pre-war price of best large coal was 20*s.* 3*d.*; at present, the controlled export price to France was 40*s.*, to neutrals 50*s.*; the Americans were selling their coal at about $6 per ton.

Lord Gainford of Headlam gave evidence last Tuesday, the 20th inst., and stated that nationalisation of the coal industry would be a national disaster. Coal, he added, was not the foundation of every industry as the miner had been taught to claim, but derived its value solely from its subsequent treatment; it was the men who treated the coal in other industries who really earned for the collier his wages. The witness then gave the coalowners' scheme for working the coal-mines, which includes a minimum or standard wage to be paid to each class of workman in each district; the fixing in each district of the particular items of cost, other than standard wages, which were to be included in the cost of production; a standard rate per ton to provide a minimum return for and redemption of the owner's capital, determined also for each district; any balance of profit remaining to be divided between labour and capital in proportions to be agreed upon, any deficiency in any quarter in the standard return on capital to be made up out of the profits of any subsequent quarter or quarters; the co-operation of workmen and owners to be by Joint Pit Committees or other local consultative committees without executive power.

At the Free Trade Hall, Manchester, on the 19th inst., between three and four thousand Westinghouse workers of all grades gathered with the management and directors. Mr. J. Annan Bryce, chairman of the company, addressed the meeting. He spoke of the setting up of works committees as a sign of the recognition of that human relationship between employers and employed which was going to be the only source of happiness for the country. The experience of the company showed that there was a real desire on the part of the workers to co-operate through the committee in endeavouring to remove grievances, in assisting in necessary disciplinary measures, in settling holidays, and the arrangement of holiday work, and in finding out how men's individual capacity could be best employed. Mr. Bryce put increased production per man as the only means of overcoming the difficulties British industry had now to face—heavy taxation and a handicapped export trade. He described as a fallacy the old idea that there is only a certain amount of work to go round, and that if a man did more he would deprive others of work. The real effect, he said, was that the more a man did the more work there was for other people, the cheaper the article he produced became, and the greater was the demand for it. The argument that because an article was sold cheaper the employer would want to pay less wages, he added, was wrong, for if the employer could sell more he could afford to pay more. The worker was entitled to higher wages and to shorter hours and to opportunity for recreation and enjoyment. If he would produce more and would welcome the adoption of every kind of improved method of machine production it would be possible not only to pay him more but to raise his standard of life.

Some time ago, says the *Glasgow Herald*, a group of about a dozen of the engineering trade unions appointed a committee to consider the question of amalgamation, the committee in its turn setting up sub-committees to consider details. The sub-committees reported to the main committee at Leicester a week or two ago, and the main committee is reporting to the representative body from which it derives its authority at York towards the end of this month. It is understood that the scheme of amalgamation which the committee has decided to recommend has a craft and not an industrial basis; the new organisation will have a large benevolent side. Various arguments are put forward in support of the decision, including a claim that "friendly benefits" have a stabilising effect on trade unionism. Four sections are recommended, with contributions ranging from 1*s.* 6*d.* down to 3*d.* a week; but all who are qualified for full membership must join sections 1 and 2. Section 4 is for apprentices. Entrance fees are to be paid on weekly instalments during the first 26 weeks, and there will be four general levies, working out at 13*s.* a quarter in all. The benefits suggested are if anything slightly higher than the average for the societies affected. The cost is estimated to work out at 1*s.* 3½*d.* per member per week. The cost to the Amalgamated Society of Engineers of the same benefits during a period of five years was 1*s.* 2½*d.*, but it is expected that the difference will be saved if amalgamation takes place. The combined membership of the organisation will be 468,339, and the combined funds will amount to 3,343,240*l.* The Executive Council of the organisation is to be composed of the executive of the Amalgamated Society of Engineers and one member of each of the amalgamating unions with a minimum membership of 10,000. If the ballot is in favour of the scheme a committee is to be appointed to draft suitable rules, which are to be submitted to a meeting of the full conference, but the committee suggest that before the vote is taken legal opinion be obtained as to the steps which are necessary in order to effect amalgamation in accordance with the law.

"NATIONAL COUNCILS AND THEIR POSSIBILITIES."

MR. T. B. JOHNSTON, of the Bristol Potteries, lecturing on the 13th inst., under the auspices of the Industrial Administration Department, College of Technology, Manchester, on this subject, said that a prototype of the modern National Council was squashed twenty-five years ago by the action of labour extremists. Thus a movement full of undoubted promise was delayed until the present time. Not till 1916, when Mr. Arnold Rowntree arranged a general conference at Shipham, was the movement rejuvenated. After a series of conferences held at Lawton Hall, Staffordshire, the National Council for the Pottery Industry was established, and its constitution formally drawn up. A unique feature of this council lies in the fact that it gives explicit assent to the principle of disclosing the average wages and profits on the turnover. So far no other council has adopted this policy. Strangely enough, this was due to the inquiry instituted by the American Government on the question of the effects on American manufacturers of British competition when the tariff was reduced from 60 per cent. to 40 per cent. This Commission established the fact that net earnings in the English pottery trade were only one-half of those earned by American, German and Austrian competitors. Including in net earnings interest, depreciation and profits, they amounted to only 5·95 per cent. on the turnover. This frank disclosure of all the facts of the case is a great influence in getting the operatives to clearly appreciate the part they play in the industry, in limiting their demands on it and in influencing generally for weal or woe its future.

A second factor of supreme importance to the success of National Councils lies in the comprehensiveness of the respective associations it represents. Unless every master be a member of the Employers' Association and every man similarly a member of his trade union, the control which the National Council may exercise over the conditions of the industry is largely rendered ineffective. Unless its authority be supreme and unchallenged it will cease to be a ruling body and will degenerate into a mere Conciliation Board such as has been established in most of our staple industries for years. This necessity has been recognised in paragraph 23 of the Whitley Report. To attain this end, to consolidate both employers and employed in their respective associations, the best method would be for the Government to grant a Charter to any industry which in the name of 75 per cent. of both parties made application for it. By making obligatory on the industry at large the ruling of a 75 per cent. majority much less friction would be caused than by directly enforcing membership and in the end the same result would be attained.

It is necessary all through that the State should safeguard the interests of the consumer at large by intimate co-operation in the work of each National Council. The future problem will not be so much the reconciliation of the claims of Capital and Labour as the holding the balance between one set of producers and another or, as in the case of the miners, preserving the interests of the general consumer. It will therefore be necessary that the work of the councils be co-ordinated under one supreme authority in the person of a Minister of the Crown who will be responsible for the commercial and industrial life of the country as a whole. Once this result attained, and our industries managed by National Councils equally representative of both parties, and these councils working in co-ordination under a Minister of the Crown, it will be an easy stage to international action, and it may well be that just as the nineteenth century was characterised by competition so the twentieth may see ushered in an era of international industrial co-ordination.

ROAD TRANSPORT.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of the 2nd inst. the able leading article on Road Locomotives and heavy motor cars prompts me to hazard the following comments. It is notorious that regulations hamper progress, it being practically impossible to frame them so as to give full freedom to development, including invention. As there is now keen international competition it behoves us to produce, handle and sell, or be prepared to sell, at competitive prices, or go under. Transit on roads is of importance second to none and should have the fullest freedom so that the transport is cheap; to be cheap there must be competition—competition between various carriers or contractors, and with other modes of transport. If this is not so, we may not be able to produce wealth—when social revolution must result. Let it be clearly understood capital and wealth are the accumulated difference between the money spent in living and the value of the work done; therefore, as the cost of living and thus of production increases, the creation of national wealth decreases and will continue to do so until we cannot pay for the imports necessary for our existence.

The higher the cost of labour, the greater the necessity for labour (saving) helping devices. Labour costs of handling goods, carrying them and repairing the roads are, therefore, of vital importance to the community. The roads should, and can, be equal to the loads, and freedom in their use must continue, provided only creative industries are not hampered. The dust, noise smell, smoke and whistling of the railways, would not be tolerated of road vehicles—which should become the chief competitors of railways in a country such as Great Britain. I got into trouble for stating at the time of the L.C.C. electrification tram that it was being done ten or twenty years too late, when in fact the trams were nearly obsolete and could not pay.

Road traction on rubber tyres on concrete roads is durable, economical, ready and adaptive, and should not be allowed to "happen," but be fostered, developed and pushed. The terminal delays and costs inherent of railways are not incurred in road transport.

To conclude, I consider it would be a mistake to hamper the use of roads and to in any way deform the natural growth of the road vehicles, provided only the noise, vibration and mess do not equal that of the rail locomotives; that rubber tyres or equivalent be insisted upon when the load per inch of wheel will settle itself in tyre durability. Trailers should be encouraged, provided twice the necessary brake power is arranged for and that they are fully under the control of those in charge of road trains. Railways are rapidly approaching obsolescence, for which nothing has been provided for out of past profits.

Yours faithfully,

May 14, 1919. A. E. PARNACOTT.

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—If I am not too late, may I claim your indulgence to reply to Mr. Walker's letter in your issue of May 9 (page 600). I have, unfortunately, been too busy "Rubbing my Eyes" to reply in time for your issue of the 16th inst.

I do not propose to answer Mr. Walker's personal criticisms of my poor literary effort, as I know from experience that Mr. Walker is far too subtle and clever with his pen for an ordinary unadvanced mortal like myself to enter into literary combat with.

But I would remind Mr. Walker that my letter was an appeal to the rank and file of the A.E.S.D. to take more interest in the Association, and see to it that the present political aspirants were not allowed to have their own way unchallenged.

Mr. Walker assures you that the actions of the A.E.S.D. are democratic, and that delegates go to the Conferences with a mandate from their respective branches, but Mr. Walker omits to mention that this mandate given to the branch representatives, may be given at a branch meeting which consists of only about 25 per cent. to 30 per cent. of the total branch membership, as instanced at the recent London Central Sub Branch Meeting previous to the conference at Birmingham.

This, I venture to say, supports my contention that the policy of the Association is carried on by the actual votes of the minority.

Mr. Walker also tells you that on all important policies a referendum is taken, and the result *presumably* acted upon. How is it then that the recent referendum on the Control Scheme having failed to obtain the necessary percentage in favour of the scheme, the said scheme is, I understand, still to be pushed forward to the branches in hopes of realising, by other means, the policy that the referendum showed was not approved by the necessary margin as laid down by the previous December conference?

May I also ask Mr. Walker in future to deal with the case in point, and not seek refuge in the byways of sarcasm and abuse.

Yours faithfully,

May 17, 1919. O. L. D.

TO THE EDITOR OF ENGINEERING.

SIR,—"Scrutator" asks whether the A. E. and S.D. took a referendum of its membership upon (1) affiliation to the Trades Union Congress; (2) affiliation to the Labour Party; (3) the increase of subscription. Upon none of these matters did the Representative Council see fit to take a referendum. Affiliation to the Trades Union Congress is the natural corollary to being a trades union, and the association balloted itself into a trades union almost unanimously. To send delegates to the Trades Union Congress binds a union to nothing, and the Council presumably thought it an advantage to watch the methods of other unions at their congress, and benefit, if possible, by their experience. That the Council did not think it of such vital importance as to warrant a ballot is not my responsibility, nor that of the Executive, nor that of any clique. It is the business of those who instructed the delegates on how they were to vote, among whom is "Scrutator."

No ballot was taken on affiliation to the Labour Party for the very sufficient reason that the proposal never got through the Conference. Had it done so a ballot would have been a legal necessity.

On the increased subscription the Council took the view that the Association could not reach its maximum efficiency without a substantial reserve fund, and that the sum fixed in the Barrow proposal was necessary to cover this, together with an unemployment insurance, and the working expenses of the Association. Some branches took a ballot of their own upon the proposal, and some wished to still further increase the figure. The amount is even now far below what such unions as the A.S.E. require.

What I wanted to make clear in my previous letter, and reiterate here, is that the policy of the Association arises from the proposals sent by the branches, and that these proposals are circulated for the consideration of all other branches so that they may discuss them, and instruct their delegates. The Representative Council, drawn from all branches, decides when a proposal warrants a referendum. It is obviously impossible to ballot upon all matters, and there may always be a difference of opinion as to where the line should have been drawn. Rule 76 is designed for such a contingency. The card vote is admittedly an imperfect method, but so far no one has thought of a better. If "Scrutator" can suggest one which is practicable democracy will be indebted to him. But under our worst conditions—conditions which would involve all branches in a simultaneous neglect to bring the matter forward for consideration at the quarterly general meetings of their members—a proposal would still necessarily have been discussed by some thousand to twelve hundred elected members of the Association who sit upon branch and sub-branch committees and councils.

The editor of the *Draughtsman* is appointed by the Representative Council; is not controlled by the Executive, nor responsible to them for the trend of his writings.

The Labour Research Department is an unique storehouse of industrial and trades union information, to which all must repair who want the latest and most reliable data. No politics are necessary to become affiliated, and the Department's assistance at 10*l.* a year, is a bargain of which all such associations as ours would be foolish not to avail themselves. This affiliation also had the sanction of the Representative Council.

It may be that the present tendency of the Association is not in accordance with the unexpressed wishes of some large section of its members. All the evidence is against any such supposition, but the sincere desire of its officials has been to ascertain and act upon the mandate of the membership. The organisation is imperfect, but has any more difficult problem ever propounded itself than that of acting with perfect equity towards all sections of a community, differing in opinions, even though banded together for a common object? In all such bodies as ours the ultimate responsibility rests upon the membership. They select and put their confidence in their representatives. If they are dissatisfied they should remove their representatives, and select others more in harmony with their views. One thing is certain—no large number of members in our organisation need have their sentiments outraged, or their opinions violated, unless they are afflicted with apathy, or the shrinking timidity of anonymous correspondents. In which case they deserve their fate. My own opinions and influence in the Association is not of sufficient importance to warrant a reply to "Scrutator's" aspersions. But for him to call my letter a "torrent of abuse" is to lay his open to still stronger condemnation. Also, there are degrees, even in abuse, and the lowest type is probably anonymous abuse.

I am, Sir, Yours faithfully,

ERNEST H. WALKER
(Chairman, National Executive, A. E. and S.D.).

May 19, 1919.

THE PATENT OFFICE LIBRARY.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the letter on this subject, which appeared in last Friday's issue of ENGINEERING, suggesting 8 o'clock as a suitable time for closing the Patent Office Library in the evening, I think it will be found that many of those who can only use the Library in the evening cannot get there before 7 o'clock, and that one hour is all too short for their purpose. I would suggest half-past nine as the closing time, should the old closing time, 10 o'clock, be objected to.

In the present revival of industries every facility should be given to those who find it a decided advantage to be able to consult the various works and records in the library, and with the far from complete subject matter indexes that are given both in technical periodicals and patent publications, often very considerable time is spent in finding the desired information.

Yours faithfully,

M. H.

ELECTRIC LOCOMOTIVES FOR THE SWISS FEDERAL RAILWAYS.—Referring to the article on these locomotives by Mr. J. Buchli, which appeared in our issue of May 2, page 564, the Oerlikon Company write us as follows:—"The trial locomotives were not calculated and designed by Messrs. Brown, Boveri & Co., alone, but by the Oerlikon Company and the Locomotive Works, Winterthur, and Messrs. Brown, Boveri & Co., and the Swiss Federal Railways conjointly. Of these trial locomotives, two were manufactured by the Oerlikon Company and the Locomotive Works, Winterthur, and they are already in service and give every satisfaction, while the two other trial locomotives ordered from Messrs. Brown, Boveri & Co. and the Winterthur Locomotive Works are not yet in service."

NITRIDES OF NICKEL AND COBALT.—Nickel has little affinity for nitrogen, and the two elements do not seem to combine directly. Two nitrides were, however, known, Ni_3N (prepared by Beilby and Henderson from the finely-powdered metal and ammonia at red heat), and NiN_4 (prepared by Curtius from nickel carbonate and nitric anhydride), and a third nitrode, the yellow-brown Ni_3N_2 has recently been discovered by A. C. Vournasos (Comptes Rendus, May 5, 1919, pages 889-891). Vournasos had previously obtained glucinum (and beryllium) nitride by oxidising the cyanide, and the similar reaction with nickel might metallurgically be interesting though it is, in that respect, rather unfortunate perhaps that cobalt follows the analogy of nickel there as in many other reactions. When nickel cyanide is treated with nickel oxide at a temperature not exceeding 1,000 deg. C., metallic nickel and nitrogen are produced according to $NiC_2N_2 + 2NiO = 2CO + N_2 + 3Ni$. When the cyanide and oxide are rapidly heated up to 2,000 deg., the nitrogen combines with the metal to form the nitride Ni_3N_2. This nitride is not attacked by boiling water, but is decomposed by acid and also by fused alkali. The corresponding cobalt nitride, Co_3N_2, is a brown powder. In the preparation of the nickel nitride the oxide NiO must be perfectly anhydrous, but it must not be heated above 200 deg. C. when being dried.

THE OPTICAL SOCIETY.

At a meeting of the Optical Society held on May 8, the President of the Society, Professor F. J. Cheshire, C.B.E., gave a lecture "*On the Subject of the Polarisation of Light.*" The lecturer commenced by explaining that polarised wave motion was the common form of wave motion noticed in everyday life, such for example, as the passage of ripples over the surface of a pond. The principle of the "polariscope" was illustrated by the action of two barred gratings through which a rope was stretched, and the analogy between this arrangement and the action of air of tourmalinesh pointed out. The production of polarisation effects by heating and mechanical stress was shown. In particular an experiment in which a cube of glass was plunged into a tank of boiling water on the stage of the polariscope, was shown. Double refraction was explained as due to "optical grain." The passage of light through a double refracting crystal was explained as being analogous to the sound waves passing along and across the grain with different velocities in wood. The subject of the rotation of the plane of polarisation, more especially in quartz, was dealt with, and many experiments were performed to illustrate this part of the subject. Finally the examination of crystals in convergent light was dealt with.

The lecture was illustrated throughout by means of projection apparatus invented and designed by the lecturer himself, an important feature of the apparatus being the form of polariser in which a modified double-image prism was employed instead of the usual Nicol. The lecturer explained that the spar required for this particular prism was only about one-eighth of that required for a Nicol prism of the same aperture.

A paper on "*Graticules*," by Julius Rheinberg, F.R.M.S., F.R.P.S., was also read. Starting with the origin of the term graticules, which are defined as the "measuring scales or marks placed in the focal plane of an optical instrument for the purpose of determining the size, distance, direction, position or numbers of the object viewed coincidentally with the scale itself," the paper discusses in detail the various methods of manufacture in this country and abroad up to the period of the war, which led to the Germans having a practical monopoly of the article except in the case of simple patterns, such as crosslines and simple patterns without numerals. This is followed by some account of the research work done during the war, which led to the production of graticules by the author, first by Grainless photography, enabling graticules to be turned out in large quantities, not only of the kinds hitherto only produced abroad, but also of many new kinds. The optical peculiarities of the various kinds are next discussed, and a chapter deals with gratical design, showing how, with the variety and choice now available, it is necessary to co-ordinate the graticule to the design of the optical instrument and its purpose as a whole. A number of new uses for graticules are put forward, and it is suggested that new applications, some of which have already been initiated, might easily lead to important improvements in may types of optical apparatus. At the same time the fear is expressed that, not being an immediately paying proposition, research work on graticules and their production by the new methods may easily go under in this country for lack of support to keep up the organisation for the same. The paper is illustrated by a series of photomicrographs of graticules made by different processes, which were taken by Mr. J. E. Barnard, F.R.M.S., and of which he has permitted publication.

The Late Mr. Carl Mumme.—We regret to have to announce the death, which occurred at Harrogate on the 15th inst., of Mr. Carl Mumme, who for many years was connected with the management of Messrs. Scott, shipbuilders and engineers, Greenock. A native of Denmark, Mr. Mumme served for some time with Messrs. Lobnitz, Renfrew, and about fifty years ago was appointed manager of Scott's yard at Cartsdyke. He became a member of the directorate when this firm was made a limited company. A few years ago he retired, and lately resided at Harrogate. Mr. Mumme was 80 years of age.

Decomposition of Liquid Dielectrics by Electric Arcs.—When the electric discharge is produced between electrodes immersed in a liquid insulation such as an oil or other organic compound, or some tetrachloride (of carbon, titanium or tin), the first breakdown of the dielectric requires a high potential, but the arc discharge can afterwards be maintained by a much lower potential. In a paper presented to the French Académie des Sciences on May 5 last, E. Urbain and Clair Scal describe some experiments of this kind made with the aid of a Tesla transformer. In order to study the reactions and the liberation of gas, which is abundant with the arc discharges, though the rupture itself liberates little gas, the temperature of the dielectric should be kept low; in hot or boiling liquids the reactions become very violent. The tetrachlorides yield chlorine, saturated hydrocarbons (petroleum) yield acetylene, ethylene and hydrogen, and sooty carbon is deposited; benzene gives similar gas products, ketones give carbon monoxide and hydrocarbons. The decomposition of oils by discharges of 10,000 volts had always been studied by Grignard at Pittsburgh; Urbain works with 1,000 volts only for the rupture and reduced that potential to half its value or 110 volts for the subsequent arc discharge. But he does not give particulars of dimensions, stating, however, that metallic electrodes have to be used, because a bridge of carbon would form between carbon electrodes in organic compounds.

DANISH ENGINEERING COMPANIES.

The report of the Burmeister and Wain Engineering and Shipbuilding Company, Copenhagen, states that the past year has been beset with even greater difficulties than the previous years, as regards the supply of raw materials. The work on new ships has been carried on at a mimimum rate, and owing to the reduction in shipping the repair business has been less than for many years past, so that from the above-mentioned causes the number of hands employed had to be materially reduced. With much difficulty the company have succeeded in effecting delivery of two large motor vessels and a steamer, but if they had not had fairly ample supplies to fall back upon, the work would have been still more restricted. Increased cost of production, foremost amongst which have been the exceedingly high prices ruling for fuel, higher wages, and increased salaries to officials on account of the high cost of living, has been the most notable characteristic of the past year.

The Diesel engine department has been very fully employed. A number of these engines in different parts of the country have been modified so as to run on peat gas, an emergency measure which has proved very useful owing to the impossibility of obtaining oil. The hammered goods department has been well employed and been of material service to the Scandinavian iron industry at a time when it was impossible to obtain this class of goods from elsewhere. The company's large workshops at Christianshavn have now been put to work, and in the shipyard material extensions are proceeding.

After practical negotiations an arrangement has been entered into with the new Danish Diesel Motor Company with regard to the manufacture and sale of Diesel engines in Denmark, and in consequence of this the projected Diesel engine works in Copenhagen have been abandoned. The prospects for the current year depend upon the supply of raw materials. If these come in as expected there will be good employment in almost every department. An order has been received from the American Shipping Board for a marine Diesel engine installation of 4,500 h.p., and negotiations are pending with respect to further contracts, Royalty contracts for the construction of Diesel engines entered into with a number of foreign firms are likely to yield remunerative results. In addition to the Diesel engines for the new vessels above referred to the company have manufactured three marine auxiliary Diesel engines, three submarine engines, and a large stationary Diesel engine installation, as well as a number of steam power plants. Both the repair and the use of the firm's floating dock show lower figures than for 1917, and the wages total has also diminished from 5,572,300 kr. in 1916 and 4,168,900 kr. in 1917, to 3,773,700 kr. in 1918.

The available profits, which amounted to 3,449,330 kr., were applied as follows: 15 per cent. of 3,202,179 kr. (480,326 kr.) to reserve and renewal fund, 5 per cent. dividend (500,000 kr.) to shareholders bonuses 623,277 kr., further 13 per cent. dividend to the shareholders, 1,300,000 kr. Further 275,000 kr. to the reserve and renewal fund, 125,000 kr. for extraordinary taxation fund, 125,000 kr. to staff pension fund, and 20,725 kr. carried forward.

The Copenhagen Floating Dock and Shipyard Company made a profit during the year of 1,526,410 kr., from which a dividend of 10 per cent. was paid to the shareholders. Of the remainder, 403,497 kr. were applied to writing-off and reserve, 39,075 kr. were added to the pension fund, 400,000 kr. were set aside for taxes, and 44,762 kr. were carried forward.

The Atlas Engineering Company of Copenhagen, made a successful start during the year with their new steam turbine which has yielded better results than were anticipated. Orders have been received for 18 sets, and these are now in course of construction. The company are carrying out material extensions to their works and plant. The net profits for last year were 553,240 kr., the shareholders receiving a 10 per cent. dividend.

The Nielsen and Winther Engineering Company, Copenhagen, which has done exceedingly well during the war and has recently taken up the manufacture of aeroplanes, only paid a 5 per cent. dividend last year.

Tools for Lens Grinding.—In a paper recently read before the Optical Society, by Mr. T. Smith, B.A., of the National Physical Laboratory, it is stated that in constructing optical systems the exact curvatures for the surfaces determined by calculation need not be employed, but the departures must lie between limits which will be functions of the nominal curvatures. It follows that a system of properly spaced tools should suffice to meet all normal requirements. The basis on which a system should be constructed is discussed, and a proposed standard list of tools is derived from an aberrational condition, together with assumed extreme relations between aperture and focal length and between aperture and radius of curvature. The total number of tools, which is finite, occurs as an independent variable in the formula on which the system is constructed, and in the absence of experimental investigations this must be determined by comparing the results obtained from an arbitrarily assumed value with the lists that manufacturers have found from experience to be reasonably spaced. A comparison between the list derived by assuming the total number of different curvatures in the complete set to be 1,000, and the lists of two makers shows satisfactory agreement. It is pointed out that the adoption of a standard tool list by a number of manufacturers would render the specialised manufacture of tools possible, resulting in the supply of ready-made tools and proof plates from stock of higher accuracy than at present, and at a reduced cost.

ROYAL METEOROLOGICAL SOCIETY.

The usual monthly meeting of this Society was held on Wednesday, the 21st inst., at the Society's Rooms, 70, Victoria-street, Westminster, Sir Napier Shaw, F.R.S., President, in the Chair.

A paper by Captain C. J. P. Cave and Mr. J. S. Dines, entitled "Further Measurements on the Rate of Ascent of Pilot Balloons," was read by Mr. Dines. The paper discusses experiments made, in continuation of previous work, on the rate of ascent of pilot balloons measured in a closed building. The building used in the present case was the Royal Albert Hall, which is very suitable for the purpose, in as much as a clear height of 40 metres is available from floor level to the grid at the centre of the domed roof. The formula in general use in this country for the rate of ascent is, rising velocity $V = q \sqrt{L} / \sqrt{W + L}$, where L = the free lift, and W the dead weight of the balloon, and q is a constant the value of which is to be determined under different conditions. It had previously been suggested that the value of q varied with different degrees of loading of the balloon. Attention was directed to this question, and quantitative results obtained. Measurements were also made with a candle lantern of the pattern used for night ascents hung below the balloon. It was found that this produced no effect upon q. In timing, the rate of ascent in closed buildings, a fine thread has generally been attached to the neck and has been drawn up from the floor as the ascent proceeded. In the present case experiments which were made with and without such a thread, showed that some correction is necessary where a thread is used. The general results confirmed the value $q = 84$, which is used at the present time, for balloons of the size generally adopted for pilot balloon work. This value gives velocities in meters per minute when lift and deadweight are expressed in grammes.

The Report on the Observations for the Phenological Year, December, 1917, to November, 1918, by Mr. J. Edmund Clark and Mr. H. B. Adames, was also presented. The excessive cold of December, 1917, was followed by three mild months, February in particular. Hence by April 1 blackthorn was in most parts blooming, whereas after the very cold early months of 1917, the mean date was 35 days later than 1918. Rarely has the farm and garden promise at this date been so satisfactory. Then came the mid-April bitter weather, disastrous to the opening fruit-tree buds, and a continuation of summer drought and coolness continued the prejudicial conditions. A genial August greatly favoured the earlier harvesting districts, but the excessive wet in September caused damage and loss elsewhere. The whole autumn was cool, but comparative dryness of October and November helped finally in the harvesting of nearly average field crops. Potatoes gave a record for acreage and yield per acre, but after storage there was serious loss from disease. The migrant records support the interesting weather relationships shown by the other tables. The April cold delayed the appearance of the 16 earlier birds two or three days more than the other 10. The isophenal lines on the map indicate the districts where the plants of Table III blossomed simultaneously. Their course shows the marked influence of elevation. On the same map are also shown the isotherms for the first half of the year, and a comparison of these with the isophenes is a matter of considerable interest. The effect of the war has been felt in the loss of many of the observers who formerly contributed to this report, and an increase in the present numbers is much to be desired, particularly in the northern districts and in Ireland.

Gases from Potash Salt Deposits.—From the statistics of gas occurrences in the potassium salt deposits in Prussian Saxony, near Staassfurt and Leopoldshall, it would appear that gas exhalations are by no means rare in these deposits in which salts of potassium, magnesium and also calcium, in general not very compact and often hygroscopic, are overlying powerful layers of the firm pure rock salt which is geologically older than the potassium salts. The statistics analysed by Gross, in the journal *Kali*, of February, 1919, cover the period 1907 to 1917, and deal in particular with 106 occurrences. In 37 of these, analyses could not be taken, because the outbursts, spontaneous or due to blasting, were too sudden and sometimes explosive. In 44 of the cases examined the chief gases were hydrocarbons; there are also oil exudations and even flows, from clefts and fissures rather than from cavities; the oil is ascribed to the decomposition of organic matter contained chiefly in the anhydrite and salt clays. The hydrocarbons are not rarely forced out under considerable pressure, but the cavities observed seemed to have been formed as a consequence of the gas escape. Several of the 11 outbursts of carbon dioxide also did damage; the gas came from the potassium salts, not from the rock salt, and in some cases, where layers of rock salt and potassium salt alternate, the feeder cracks could be traced through the rock salt. Outbreaks of sulphurretted hydrogen were recorded on four occasions, exhalations of the gas are not rare; in one instance carbon disulphide seemed to have been liberated, though its presence could not actually be proved. Nitrogen outbursts were reported in three cases, hydrogen outbursts also in three cases; the nitrogen is always liberated under pressure. Hydrogen is also frequently found in cavities and associated with helium and also with neon; but the gases are not under any noteworthy pressure. It is assumed that the helium is of radioactive origin, radium salts having possibly been deposited together with carnallite (a hydrated double chloride of potassium and magnesium); if, however, the nitrogen be of atmospheric origin, as is believed, the helium might come from the same source.

DESIGN AND CONSTRUCTION OF FLYING-BOATS.*

By CAPTAIN DAVID NICOLSON (Associate Member).

INTRODUCTION.

DURING the war information regarding the progress in design and details of construction of aircraft was rigidly guarded by the Defence of the Realm Act regulations, consequently little has been published on the subject of flying-boat design or construction, and what follows may, to a certain extent, remedy the deficiency at least from the practical standpoint.

Within the limits of a paper it is not possible to treat the subject exhaustively, and I merely propose to deal mainly with the construction of the larger types of flying boats, known officially as F. 2A, F. 3, F. 5, P. 5, and N. 4.

Of these, the F. 2A has the smallest hull, which measures 42 ft. 6 in. in length and 10 ft. in breadth, and is 2 ft. 6 in. shorter than the F. 3 and F. 5 types.

The P. 5 and N. 4 types, patented by Major Linton Hope, are entirely different in design and construction from those above mentioned. Being of circular cross-section, with fair and easy lines, they offer much less air resistance, consequently with the same horse-power are driven at higher speeds; they are much stronger weight for weight than the F type, more seaworthy, and generally show the impress of the trained naval architect's hand.

In comparison, the F type follow more closely the aeroplane body, an attempt having been made to attach a flying-boat fore body to a fuselage tail. Compromises are seldom successful; the tail proved to be both weak and unseaworthy, and it was found necessary to considerably strengthen it by additional planking. As, however, this class was already slightly tail-heavy, the additional weight did not improve matters. Having rectangular sections, they were actually weaker in transverse strength than the Linton Hope circular design.

DEVELOPMENT OF FLYING-BOAT DESIGN AND CONSTRUCTION.

The first flying boat in the British service appears to have been the "Donnet Leveque," a French design, which was followed by the Sopwith bat-boat and the Curtis small "America," which developed later into the White and Thompson and the Norman Thompson N.T. 2B) types.

A larger Curtis boat, with twin engines, built in the United States, was in use for the North Sea patrol, and was probably the worst example of boat building that could be imagined, it having had no less than four consecutive planks butted—not even scarphed—on the same timber, which had a siding of only ¾ in., the line of butts being in line with the step where the boat was naturally weakest.

Other early boats were the Saunders small "America," midway in size between the 24 ft. 6 in. White and Thompson boat and the 33-ft. twin-engined Curtis, the Nieuport, and the F.B.A. The two latter were of French design, and the last mentioned was largely used for training purposes; in this respect also the N.T. 2B has done excellent service.

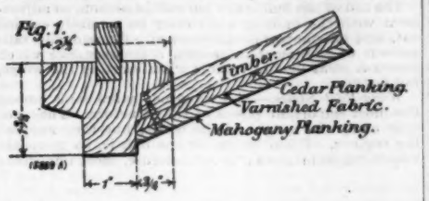
The White and Thompson boats were built by Messrs. Saunders, of Cowes. These and other hulls were excellent examples of good work, but the system of their multi-skin-sewn construction proved inefficient as the wire sewing, sunk flush with the surface of the outer skin, cut into the soft cedar when the boat was subjected to severe landing shocks, &c. Another source of trouble was the combination of a more or less flexible structure with a series of rigid bulkheads which did not prevent movement of the parts of the structure between them, with the result that distortion occured, resulting in considerable damage.

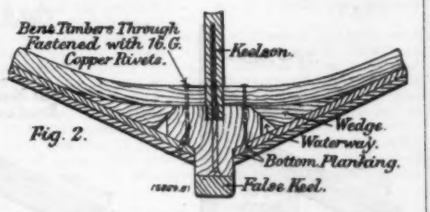
The Curtis boat, as originally built, was wall-sided, i.e., without projecting side fins to the front step and planing bottom, but as it experienced difficulty in getting off the water, the breadth of the step was increased by adding fins, thereby improving the planing efficiency, although the fins in service were very liable to damage.

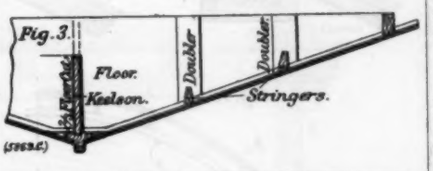
A number of modifications of the Curtis design were built at the Royal Naval Air Station, Felixstowe, to the plans of Colonel Porte, who was responsible for the design of the first large flying boat, known as the "Porte Baby," which was built by Messrs. May, Harden and May. Although these "Porte Babies" were all constructed under the best conditions with respect to material and workmanship, they were inherently weak in bottom, especially at the step, owing to the faulty design of the keel, which was of spruce, and very small in section to the tail.

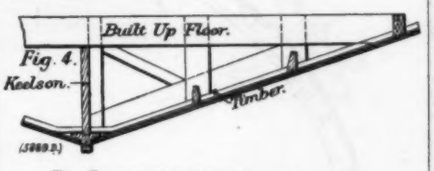
American-built Curtis boats of large size were later on imported in considerable numbers, but although the workmanship and materials were much improved, they were still weak owing to a lack of continuity in the structural design, and frequent damages were reported, until Lieutenant-Commander Hope-Vere (then in command of the Royal Naval Air Station at the Scillies, where these boats were kept afloat at moorings) stiffened up the bottoms with bent timbers and stringers. Boats of the F type which followed were a great improvement on the Curtis type, and were fitted with engines of considerably greater power, but, as in previous boats, the bottoms gave trouble owing to the faulty keel and floor construction.

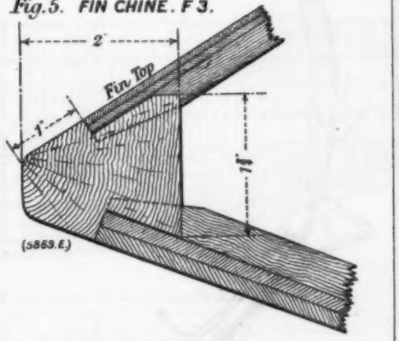
While these various types of boats were being built at Felixstowe and in the United States, the 30-ft. A.D. boat was designed at the Admiralty, and a number of hulls were built. This was the first flying boat to be built on the system of resilient construction, and the hull proved to be extremely strong. Shortly afterwards, during the early summer of 1916, a 41-ft. boat was designed by Major Hope and a model tried in the William Froude Tank at the National Physical Laboratory, Teddington. The chief feature of this design, apart from form and light hull construction, was the much greater proportion of power to weight (15 lb. per horse-power) than in the existing boats, and there is

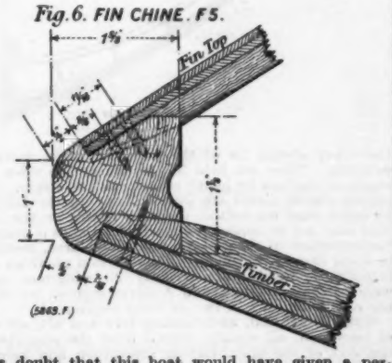












little doubt that this boat would have given a performance far ahead of any existing boat or seaplane, with the exception of the little Sopwith "Schneider." Unfortunately, there was strong opposition to this design, and it was rejected in 1916. The "Phœnix Cork" was built to a somewhat similar but improved design on slightly increased dimensions, and proved very successful, being far ahead of anything previously accomplished.

CONSTRUCTION. TYPE F.

The construction of the F type is on the box-girder principle, with four longerons running fore and aft. The keel, another fore and aft member, runs from the sternpost right round the nose to form the stem, and finishes at the gun ring. The keel and keelson combined with the floors form the backbone of the hull. That the keel is of faulty design is the opinion of the writer, for many boats were found to leak badly, partly due to the bad connection between the keel and bottom planking, and partly because the keel is too narrow. The keel and planking are fastened as in Fig. 1, but only one row of brass screws secure the bottom planking to the keel in the hulls of the F. 3 type.

Another weak point is the discontinuity of transverse strength caused by running the timbers down to the keel and stopping them there, no provision really being made to hold the centre girder to the bottom planking or sides of the hull.

In the F. 5 type the timbers are continuous from fin chine to fin chine, as in Fig. 2, forming a much stronger combination. The keel was increased in depth to 1 11/16 in., the width being kept the same, namely 2½ in. It would have been much better if the siding had been increased instead of the moulded depth. The bottom planking is again only fastened with one row of brass screws, which is insufficient. However, a great improvement was made by the continuous timber, as they were through fastened to the keel by copper rivets.

Keelson.—The keelson is fastened to the keel in the F. 3 boats by brass screws 18 in. apart, but in the F. 5 type the spacing is 9 in. and the screws are hove up through bottom of the keel. Although the keelson in some parts measures nearly 12 in. in depth, it is greatly weakened by having one-third of the depth cut out to accommodate the floors.

Floors.—It will be seen from Fig. 3 that two-thirds of the depth of the floor is cut away, thereby sacrificing strength to accommodate the keelson. A built-up floor, as in Fig. 4, would certainly be much more effective, and would be probably 40 per cent. lighter.

Timbers.—The timbers are of American rock elm, ¼ in. by ¼ in., spaced 4 in. apart amidships, increasing to 7 in. at the ends of the boat, and terminate at the lower chine; but it would have been an improvement had they been carried to the upper chine. The timbers are through fastened to the keel by copper rivets.

Bottom Planking.—This is arranged on the diagonal system, the inner skin being of cedar ¼ in. thick at the ends and 5/16 in. thick amidships, fitted at an angle of 45 deg. inclination to the keel. The outer skin is of mahogany, 5/16 in. thick forward, 3/16 in. thick amidships, and ¼ in. thick aft, the planking being at an angle of 30 deg., with the forward end of the plans butting against the keel. This arrangement tends to diminish surface friction in wake of the seams. A layer of varnished fabric is fitted between the two skins, making the structure very strong. The planking is fastened together with copper nails, and to the floors and stringers with brass screws. Along the keel and fin member it is connected with brass screws 1½ in. apart.

In the earlier types of boats the planking was 5 in. in breadth, with the rivets widely spaced, but it was found that with this breadth the atmosphere affected such thin material, and opening of the seams resulted. The planking was afterwards cut down to 3½ in. in breadth. It was also found necessary to keep the rivets very close to the edge of the planks, as there was a tendency for the planks to buckle. The bottom planking extends to the fin chine, which runs from the bow for fully two-thirds of the length of the boat.

Figs. 5 and 6 illustrate the connection of the planking with the fin chine in the earlier and later types of boats, and it will be seen that the back rabbet for the planking of the fin top and fin bottom is more workmanlike in the former than in the latter, which is less than 1 in. in length. By having only ¼ in. of material between the ends of the fin chine and the planking, a boarding boat coming alongside might cause the planking to spring, as such a meagre allowance is inadequate to prevent an accident of this kind.

Fin Top.—The timbers under the fin for the early F. 3 hulls were heavy and widely spaced, but in later boats timbers ¼ in. by 5/16 in., spaced 2 in. apart, were substituted to permit all through fastenings of the diagonal planking on the hardwood timbers. It might also be stated here that the fin top of the first series of F boats was of three-ply birch, and in later types was covered with fabric and varnished. The introduction of diagonal planking was a great improvement on this system. All the fins on the F. 3 class are flat, but the F. 5 types have a ¼-in. camber, which adds to the strength, gives a better appearance, and assists in getting rid of water easily.

Stringers.—Two stringers, equally spaced from the fin member, run under the fin, and two other stringers placed immediately below these on the bottom are connected by ¼-in. square posts placed 1 ft. apart. Intermediate stringers, 16 ft. long, are introduced in the fore part of the boat to further strengthen the shell and to absorb shocks when the hull alights in the water.

Fin Member.—In the first boats of the F type the fin member, Fig. 7, was of American rock elm. On account of the improper connection between the side of the hull and the fin top, the longitudinal seam naturally opened up, so in later hulls the fin member was constructed as in Fig. 8, which has the member and bead in one. This in turn might be improved by rabbeting out a piece at the back to allow the sides to house correctly as in Fig. 9.

Bow and Nose.—The timbering at the bow is composed of rock elm, ¼ in. by ¼ in., spaced 2½-in. centres apart, and reinforced by horizontal stiffeners below the top longerons. These are spaced to take the outer seams of planking, tapered towards the stem, and connected to the same by small oak breasthooks. These breasthooks bind the two sides of the bow together at the

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, April 29, 1919.

juncture of the stringer and stem, thus forming a very strong combination. Above the top longeron there are ten deck-stringers, which are notched to take the ribs, together with three strong beams which subdivide the athwartship ribs. This skeleton, which is shaped like a dome, is planked diagonally, the inner skin being laid at 45 deg., with the forward ends of the plank lowermost. The outer skin is laid approximately fore and aft to suit the curve of nose. Each skin is of mahogany, $\frac{1}{4}$ in. thick, the planking being fastened to strong beams with wood screws. Where stringers and ribs occur, copper nails are driven through and fastened on grooves on the inner skin; elsewhere the planks are fastened with copper nails spaced about 1 in. apart. This work, being well constructed, adds greatly to the appearance of the boat, and although the bow is slightly heavier than the rest of the hull, it is the best piece of construction in the whole boat. Strength at the nose or fore end of the structure is very essential, for at high speeds the resistance of the air is very great at this point, and a weak nose would be very easily damaged and driven in.

Sides.—Abaft the bow planking, the sides are of three-ply birch, and extend from the bottom of the fin member to the top longeron, running aft to the gun-port openings, a distance of about 18 ft. The three-ply boards are butted against the side stanchions, thus saving buttstraps. Up to within a few months ago, the sides abaft the gun-port openings were built up of a narrow strip of mahogany, with fabric stretched between the same and the upper longeron. The fabric was not strong enough in anything like rough weather, nor under bad handling in fine weather, and the tails were weak in torsion; it was therefore superseded by diagonal planking of two skins, each $\frac{1}{8}$ in. thick, with nainsook between. This planking was fastened to timbers, running from longeron to longeron, spaced 2 in. apart, with one stringer midway running fore and aft. The new tail planking was a great improvement, although it added about 47 lb. to the weight of the hull; but experience has justified the change and extra cost. Several of the latest hulls have the sides covered with two-ply "consuta," made up of two pieces of very thin mahogany sewn together with flax thread, which is lighter than riveted work.

Top of Hull.—The transverse strength is made up of beams and arches combined with spruce stringers spaced about 7 in. apart. The top of the hull has many openings, the foremost being a 30½-in. diameter gun ring; about 3 ft. abaft this there is the pilot's hatch, 4 ft. by 2 ft. 3 in.; and 6 ft. further aft there is the wireless operator's hatch, 1 ft. 10 in. in diameter. The engineer's hatch is placed on the port side, immediately abaft of which is a three-ply footway extending across the hull. About amidships there is a second 30½-in. diameter gun ring. Another opening accommodates the wireless mast, and lastly there is an 8-in. triangular ventilator.

The deck is built and covered with fabric, and the stringers decrease to a minimum, in order to keep the tail weight as low as possible. Naturally the longer and heavier the after part of the tail is the greater is the bending moment and tendency to shear, and as the extreme end has to carry the rudder elevators, &c., the designer aims at keeping down weight consistent with strength in this part of the structure.

Bulkheads.—These are four in number, each running from the top of the floors to a few inches above the top of the fin line. They are of $\frac{1}{16}$-in. three-ply birch, stiffened by diagonal spruce stiffeners. The top of the bulkhead is stiffened by a capping piece of spruce. Where a bulkhead came in line with a floor, it was necessary to fit a packing piece between the floor and the bulkhead, except amidships, where the keel is practically horizontal.

Where elevator control wires pass through a bulkhead a fabric stocking-joint with brass washer plates on each side keep the bulkhead watertight, and where centre bracing struts pass through, a three-ply watertight collar is fitted.

Metal Fittings.—The chief elements of the structure, such as struts, pillars, beams, floors, wing-root spars, &c., are held and bound together by light metal fittings of about 16 B.W.G. steel.

The fittings were so numerous in the F type that they had a considerable influence on production during the war, and in consequence they had to a great extent been eliminated in the P and N type, with the exception of the external stay tube plates and mooring eyes.

Painting.—The inside, as far up as the fin top and the end of the tail, is coated with bitumastic paint, while the remaining portions are well varnished.

The bottom outside is painted with a special flying-boat black anti-fouling composition. The first hulls constructed had the bottoms varnished, and when the third coat was still "tacky," blacklead was rubbed in and the surface polished. This treatment proved excellent, but it involved a considerable amount of work at the air stations keeping the bottoms in good condition. Blacklead was applied for the reason that, when the bottom was almost dry, it could be polished to the smoothness of glass, thereby greatly assisting the hull to get off the water when driven at high speeds.

As an experiment, one hull was covered on the bottom and fin top with velure paint, which gave satisfactory results, and it was found to be lighter than the covering of varnish and black lead.

The outside work did not required to be painted, such as the nose planking, hatch coamings, three-ply work on the topsides, top of fins, and the outside of the tail, receives three good coats of best varnish.

Two coats of black stove enamel are applied to all the steel fittings.

Bracing.—The longerons combined with the struts and stays form the principal superstructure of the hull above the fin top. From the nose to the gun-port openings these vertical and diagonal struts are of spruce, moulded to give the greatest strength with lightest section. Abaft the gun-port opening to the sternpost the vertical and horizontal struts are of 1-in. mild steel tubes, braced diagonally fore and aft and transversely with 10 B.W.G. wire, all the wires being adjusted by turn-buckles.

The tail of the hull is not too stiff in torsion, so adjustment with the bracing wires must be carefully carried out, and all the turnbuckles locked. Occasionally tails get out of alignment in transit, a circumstance which causes a great deal of trouble when erecting the wings, tail fin, etc.

Wing-Root Spars.—The wing-root spars rank among the most important pieces of the structure. They not only carry the weight of the wings, but they support the engines. When in the air the hull is, so to speak, suspended from them; it is, therefore, most important that they should be of the finest and best material available. They are held in position at the sides and centre of the hull by heavy stanchions and struts. The centre bracing-struts are slotted, let over the keelson, to which they are bolted, the ends resting on the keel. This may not be considered good practice, as it compels concentration of thrust in a small local area, resulting in some cases to springing of the bottom planking and fastenings. Until quite recently all wing-root spars were of solid-section grade A silver spruce, but these are now laminated in two or three sections.

Outside the hull, and running fore and aft, six ribs of basswood, all equally spaced from the longeron to the end of the spar, further strengthen and help to keep the spars in place. These ribs have two small stringers passing through them, giving firmness to the structure, which in turn is covered on top with three-ply birch, and on the bottom the fabric is stretched from the leading edge to the trailing edge, the whole forming the wing roots.

Interior of Hull.—The bottom deck is of sparred spruce-boards, varying in width from 3 in. to 4 in., screwed to the top of the floors.

At amidships, where the petrol tanks are stored, the floors are shaped to take the tank stools, and are specially stiffened and built up at the sides to form the tank cradles.

Accommodation for a gunner is located immediately below the fore gun-ring, and a table for his use extends from his seat to the nose of the hull. Underneath the table is carried an ammunition box and trays. The hinged seat, which has a high back, is made of three-ply wood, except the rails and supports.

Abaft this seat is the station for the pilot and assistant pilot, so arranged as to give a proper look-out. Their seats are well upholstered with kapok cushions, which act as lifebuoys if required. The assistant pilot's seat and back is made to hinge, so that a clear passage may be obtained for walking fore and aft. A few feet behind the pilot is the wireless cabinet, with operator's seat, while at the port side of this a ration box is fitted. The engineer's accommodation is situated aft, with a ladder giving access to the top deck. Further aft is the second gun-ring, with an adjustable platform, to allow the gunner to have a good range of heights above or below the gun ring.

Fig. 1.

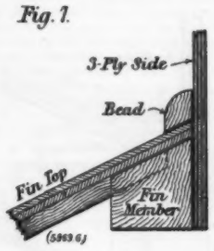


Fig. 8.

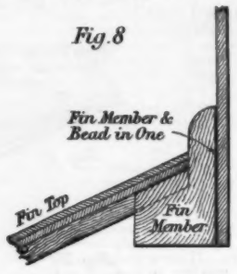


Fig. 9.

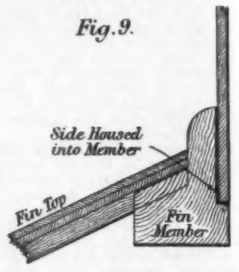
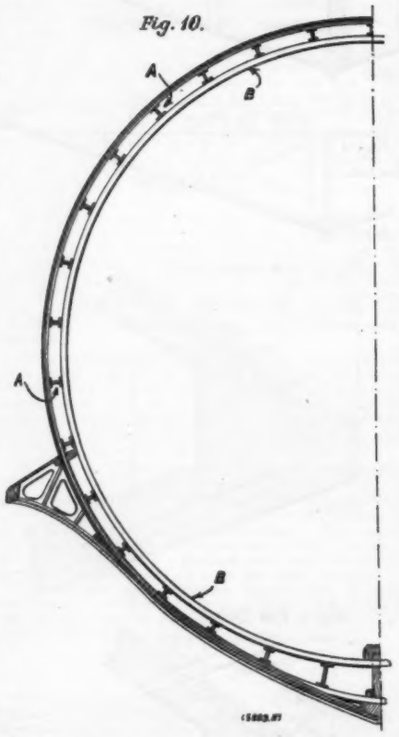


Fig. 10.



Steps.—The steps of the F. 2A and F. 3 boats are framed with ash bearers $\frac{1}{4}$ in. thick, and are 3 in. deep at the after edge, tapering to meet a board which runs off to a feather edge forward.

The bearers are spaced about 5 in. apart, and through fastened to the bottom planking; where the timbers come in the way, they also take the fastening. The bearers are joggled to take the step timbers, which are of ash, $\frac{1}{4}$ in. by $\frac{1}{16}$ in., spaced about 2 in. apart. The inner skin of the planking is of $\frac{1}{16}$-in. cedar, and the outer skin of mahogany of the same thickness, both laid diagonally. The whole step is constructed at the bench, fixed in place, and screwed on to the bearers.

At the forward edge of the steps a 6-in. copper band of light gauge covers the edge of the step, the forward edge of which is sunk into the bottom planking.

Trouble was experienced with the feather boards swelling, and in some cases coming away altogether, due to the "tearing" or frictional resistance of the water when the hulls were driven at great speeds just previous to their getting off. This was remedied in the F. 5 boats by carrying the inner skin of the bottom right through from end to end of the boat. The outer skin abaft the back step was then put on and carried forward to a feather edge under the back step, while a short false inner skin was fitted over the usual step framing and then attached to the bottom skin. The outer skin between the steps was put on from the after end of the back step and worked forward to a feather edge under the main step with a false inner skin as before. The outer skin of the fore bottom was then carried right over this from the after side of the main step to the stem. This construction is much stronger, and a great improvement on the former step.

Generally the hull construction of the P and N types consists of a number of stringers disposed, as in Fig. 10, around the more or less circular section of the boat.

Stringers.—The longitudinal stringers, A, Fig. 10, are of spruce 2½ in. moulded amidships tapering to 1 in. forward and ½ in. aft, all sided $\frac{1}{16}$ in. At the top and bottom of each stringer are glued a pair of fillets, one on either side of each stringer, to take the fastenings through the floors and the skin. The writer suggests that I-shaped stringers should be worked out of the solid, forming a lighter and stronger girder.

The stringers are secured to the interior bent-wood hoops, B, of rock elm, extending in planes transversely to the longitudinal axis throughout the length of the boat, Figs. 10 and 11. The hoops are doubled in wake of the wing-root spars, and alternately scarphed at the top and bottom. Externally around the longitudinal stringers are a number of bent-wood ribs or timbers of rock elm moulded $\frac{1}{16}$ in., sided ⅜ in., and spaced 2 in. apart, except at the bow, where they are fitted as cant timbers and spaced 2½ in. apart. All timbers are in one piece, bent right round the hull with the ends at the keel, into which they are joggled and glued to the stringers.

Floor-Timbers.—The bent floor-timbers are of rock elm ½ in. moulded, sided ⅜ in. at the centre of the keel, and tapered to ¼ in. moulded and ⅜ in. sided at the ends, all embracing one-quarter of the hull, thus ensuring perfect transverse continuity of strength in the timbers. The keel is of rock elm moulded 1⅜ in. and sided 3 in. at amidships and tapered at the ends. It is in one piece, and runs up to form the stem, and is a great improvement on the construction adopted in the F type.

Keelson.—The keelson is of spruce, 5 in. moulded at amidships and tapered to stem, and to 2 in. at the after end. It is sided ½ in. parallel throughout. The bottom is carefully joggled over the floors, and glued and secured to the keel by two spruce fillets glued and through fastened to the keelson, keel and floors. The top side of the keelson is rabetted into the under side of a top member or flange, which is secured by glue and screws. This top member or flange is of spruce moulded ½ in.

at the centre and tapering to ⅜ in., sided 2½ in. at the centre, tapering to stem forward and to 1½ in. aft; the keel, keelson, and top member forms a very strong I girder.

The sternpost is of mahogany moulded and sided, and extends to 1 ft. above the hull. Saddle straps of elm are fitted, as shown on Fig. 11; those at the main spars and tail-plane struts are in one piece running round the boat with their ends fastened to the keel, as in the case of ordinary timbers, and of the same thickness. In addition, doublings of English elm are fitted at the wing-root stay plates at the front and rear spars; these are clearly seen in Fig. 12.

These doublings are carried in a fore and aft direction for a length of 30 in., and are carefully joggled over the timbers and floors. The planking of Honduras mahogany is fitted in narrow widths with close seams. The inner skin ⅛ in. thick being laid diagonally, while the outer skin ⅛ in. thick,, of the same material, is laid fore and aft.

Varnished nainsook is laid between the skins; this not only makes a watertight job, but adds to the strength of the stem chine. The inner diagonal skin is held in position with copper pins, the outer being through fastened to the timbers with copper nails, the ends of which are turned on the face of the timbers.

Outside the main structure already described, a double-bottom or water-planing surface is fitted, and known as the step. The water-planes are framed up forward of the main step with three-ply birch and small stiffeners, the frames being spaced 18 in. apart, and secured to the inner hull planing-bottom with spruce fillets.

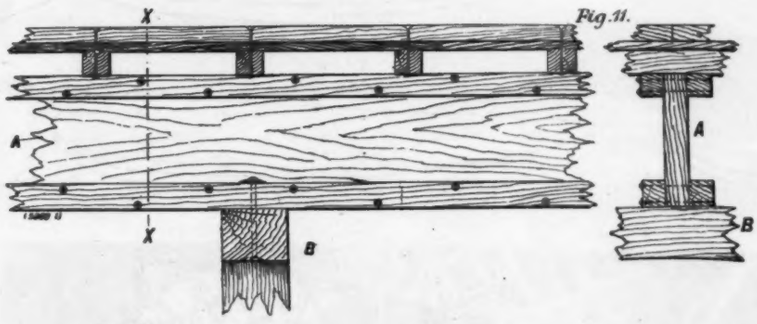


Fig. 11.

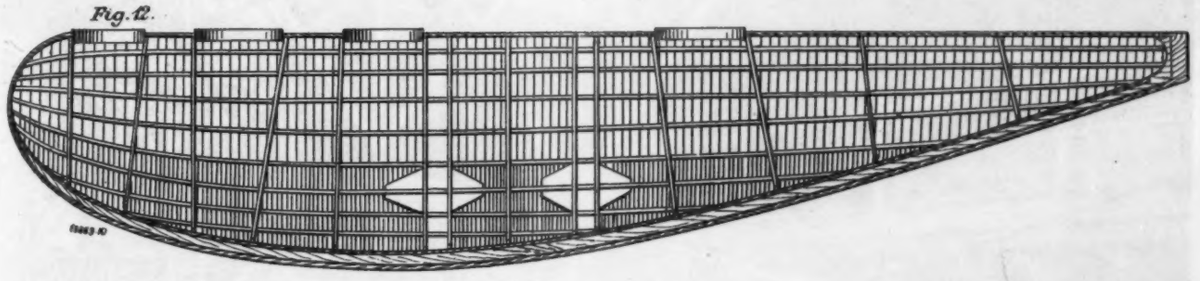


Fig. 12.

TABLE SHOWING THE RELATIONSHIP BETWEEN THE PERFORMANCES OF SOME OF THE BOATS.

P. 5.		F. 3.		F. 5.	
Two Eagle VIII Rolls 352 h.p., 1,800 revs.		Two Eagle VIII Rolls 345 h.p., 1,800 revs.		Two Eagle VIII Rolls 345 h.p., 1,800 revs.	
	lb.		lb.		lb.
Weight empty	7,437	Weight empty	7,958	Weight empty	8,023
Petrol, 100 gallons		Petrol, 100 gallons.		Petrol, 80 gallons.	
Oil, 20 gallons	915	Oil, 10 gallons	836	Oil, 10 gallons	688
Miscellaneous	138	Miscellaneous	238	Miscellaneous	199
Crew	720	Crew	720	Crew	720
Total weight	9,210	Total weight	9,752	Total weight	9,630
	lb.		lb.		lb.
Weight per square foot of surface	7·12	Weight per square foot of surface	6·82	Weight per square foot of surface	6·83
Weight per h.p.	13·10	Weight per h.p.	14·13	Weight per h.p.	13·95
	Mins. Secs.		Mins. Secs.		Mins. Secs.
Climb to—		Climb to—		Climb to—	
2,000 ft. 2	40	2,000 ft. 3	12	2,000 ft. 2	45
5,000 ft. 7	55	5,000 ft. 9	3	5,000 ft. 7	30
Speed at—	Knots.	Speed at—	Knots.	Speed at—	Knots.
2,000 ft.	91	2,000 ft.	81	2,000 ft.	86
5,000 ft.	89	5,000 ft.	80	5,000 ft.	87

Chine.—The chine of rock elm is in one piece, and tapered from 1½ in. by 1½ in. at the front step to 1¼ in. by 1 in. at the stem. The stringers are of spruce, all in one piece fore and aft, fitted through the three-ply frames, which are fixed to the stringers by small fillets. The timbers of rock elm of the same size and spacing as in the main hull, with the ends joggled into the chines, are tapered to fit the hull; they are secured to the face of the stringers with glue and light copper pins. The bottom is planked with a double skin of mahogany with varnished fabric between, similar to the main hull.

Fin Top.—The fin top is framed with rock elm timbers spaced 2 in. apart, the ends being joggled into the chines and into a fillet of rock elm. The whole is planked in a similar manner to the inner hull, carefully fitted to the chine, and hull-fillet rabbets and closely fastened with screws. Rubbing plates of ⅛-in. brass, bent to the shape of the bottom, are fitted along the keel, and the chines are also protected by brass strips fastened to the sides and bottom, with the fore ends let in flush and secured by screws.

The bulkheads when fitted are of waterproof canvas fixed to hoops, the spaces between the hoops and skin being filled in with compressed cork to make a thoroughly watertight job. This part of the structure is elastic, and can be considerably distorted without damage, forming a natural buffer to withstand sudden local shocks or bending moments on the hull structure. A strong point in favour of the small transverse framed hull is its resiliency, as it does not depend for its efficiency upon the rigidity of the parts comprising it.

The following are a few of the advantages of the P and N type of hull over the F type:—

(*a*) A saving of 29 per cent, in bare hull weight in P 5 over the latest hulls of the F 5 class, which are of the same length and power.

(*b*) An increase in torsional stiffness of the after part and probably greater strength generally. This was proved by testing one of the earliest types to partial destruction at the R.A.E., Farnborough, to ascertain the bending moment when supported at the ends, and the effect of crushing by loading the bottom up to 17 lb. per square inch of its surface.

(*c*) The cost of production compares favourably with the F type. The man-power hours on the 64-ft. hull is 7,500 or 5·37 per square foot of surface; while the time required for completion is 14 weeks, the approximate cost being 1*l.* per lb. weight, including stay-tube plates and steel fittings.

(*d*) This system ensures extreme accuracy in the estimating of weights and the centre of gravity, *e.g.*, the smallest boat had an estimated weight of 216 lb. Two hulls built by different firms only varied by ½ lb. Three hulls of an estimated weight of 430 lb. actually weighed 436 lb., 437 lb. and 440 lb. respectively, and were built by three different firms. The greatest variation in position of centre of gravity was ½ in. from that calculated. The largest yet built, N 4, is 64 ft. in length, and her estimated weight was 2,970 lb.; the actual weight being 2,982 lb., an error of 12 lb., or less than ½ per cent. The position of the centre of gravity in this case was exactly as designed.

IMPORTANT FEATURES.

In a flying boat it is necessary for efficiency that it should possess—

(*a*) A minimum weight of hull consistent with strength.
(*b*) Seaworthiness.
(*c*) A minimum hull resistance.

Military.—A capacity for carrying guns having an all-round fire, and for dropping heavy bombs.

Commercial.—Large passenger and mail-carrying capacity.

(*a*) The military flying boat, not being built under the registration societies' rules, has no unit to limit the reduction in weight, therefore every action is taken to keep the scantlings and fittings very light, so that the boat might carry as much petrol as possible for long-range work, and a large armament. To reduce the weight from the original design was rather a difficult proposition, as some pilots and equipment officers made continual demands for additions such as wireless apparatus, signalling lamps, life-saving apparatus, boat-hooks, sea anchor, carrier pigeons, &c., which were found necessary under service conditions.

It should always be borne in mind, however, when designing a flying boat, that its operational value depends entirely upon the weight of the machine when it is empty.

(*b*) Any machine which has to alight on the water, and remain there for any length of time, must be seaworthy. It is here that the flying boat has proved to be a great improvement over the seaplane. It has sometimes happened that a seaplane alighting on rough water has been completely wrecked in a very short time by the force of the waves, while several have been blown over. As seaworthiness depends on the design and construction of the hull, a make-shift between an aeroplane fuselage and a flimsy boat is not altogether desirable.

It is as essential that the hull should be designed by a naval architect and constructed by a shipbuilder as the hull of a 20,000-ton steamer, to enable it to fulfil all the conditions of a trying service. Possibly in the near future these boats will be built to rules evolved by registration societies.

(*c*) The form of a flying boat is of the greatest importance not only from the point of view of displacement and stability, but from the standpoint of resistance in smooth or disturbed water, or in the air as affecting speed. Many tank experiments have been carried out to find the most suitable form for certain fixed conditions, and following are some of the conclusions arising from these investigations:—

Hollow V sections keep the spray down, cut the water more easily and cleanly, plane better, reduce shock on landing or when ploughing through broken water, and eliminate the necessity for shock absorbers. In some of the latest boats the forward sections show a V or concave curvature, blending sweetly into a convex form, which has been found desirable in order to give the fore part of the boat buoyancy when she first takes the water.

The bottom of the hull forward should be inclined to the axis of the machine, but the inclination must not be so great as to cause planing before the controls become effective, and this is particularly necessary when running before the wind. If planing is too pronounced, the boat rises on the surface with but very little control available to maintain balance, which might prove fatal, and when running before the wind this is more likely to occur, due to the higher water-speed necessary before the machine can take the air.

Aft, the bottom should rise quickly, as this favours a steepening of the planing bow before suction is eliminated, and allows the tail to be well clear when planing begins. This is particularly noticeable in the F.B.A. boats, a French design in which the naval architect boldly swept the after part of the hull upwards in curve form.

The total resistance of the P and N type takes precedence over the F design. The former types are more stream-lined in shape, and their bows are much finer. The excessive round bow of the F type was adopted to allow the forward gun to be fired over the stem and below the boat; but this shape could be greatly improved and yet attain the former object. It will be seen from the sections, Fig. 13, that the area of the F type bottom is greater than that of the P type, consequently surface friction in the latter is much less than in the former; but although this is a disadvantage for the F boat, it gives a larger water-line area, and should necessity arise for adding extra weights the immersion would be less than in the P type, which

would counterbalance to some extent the disadvantage stated.

As in aeroplanes, the struts and wires are all streamlined to give the least possible resistance, a feature proved in practice to have a beneficial effect on the maximum speed of the machine.

(*d*) The primary object of the flying boats was to bomb submarines, but they also proved useful for patrol and scouting work. Although they were intended for offensive purposes, they were also prepared for defensive action, and were fitted for carrying machine guns. The position of two of these guns has been previously stated; other two are placed a few feet abaft the rear spar and inside the hull, two larger gun-port openings or doors concealing these weapons from outside view. The latter position is not an ideal one, for they cannot fire below the boat, and their fore and aft radius of fire is limited. It would be an improvement if a watertight hatch were designed in the bottom of the boat, clear of the steps, to enable a gunner, when the boat is in the air, to fire directly downwards into an opponent.

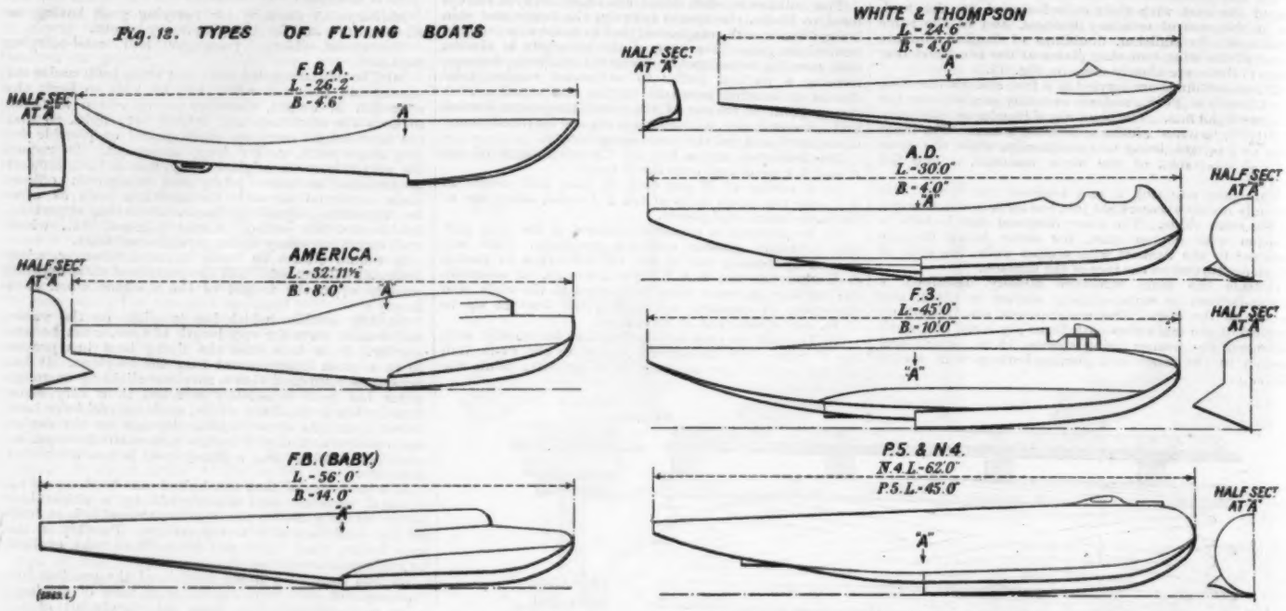
Heavy bombs, in some cases weighing up to 500 lb., are carried, hanging in a horizontal position at the ends of the wing-root spars; these are released instantaneously by gear controlled from inside the hull.

(*e*) It may be interesting to review the results attained, and to consider how far these, twelve years after flight became an accomplished fact, are likely to influence future progress. Money, time, and brain power have been spent upon the development of airships, but it is doubtful whether the best of the non-rigid or the rigid types have ever yet justified their cost, and, so far as can at present be seen, no great improvement in this respect is likely to take place. The lift of a lighter than air flying machine can never be greatly increased, even if a gas were discovered weighing zero, as the increased lift obtainable would be practically negligible.

German airships did valuable scouting work for the enemy, but as fighting machines they had a decreasing value. For commercial purposes, it is questionable if the enormous cost of production and maintenance will ever be decreased so that mails and passengers may be carried as cheaply as by other means of transport. Undoubtedly mails will be carried regularly and to a large extent between important seaports in the near future, and there are other ways of profitably employing flying boats—for the purpose of spotting derelicts, fighting forest fires, locating drifting mines, and even for proposed expeditions to the North and South Poles.

The flying boat is probably the only machine by which rapid communication can be opened up in dense forest country intersected by rivers which cannot be navigated owing to falls or rapids, for such boats can alight on any moderately sheltered water, and require no special aerodrome.

Fig. 12. TYPES OF FLYING BOATS



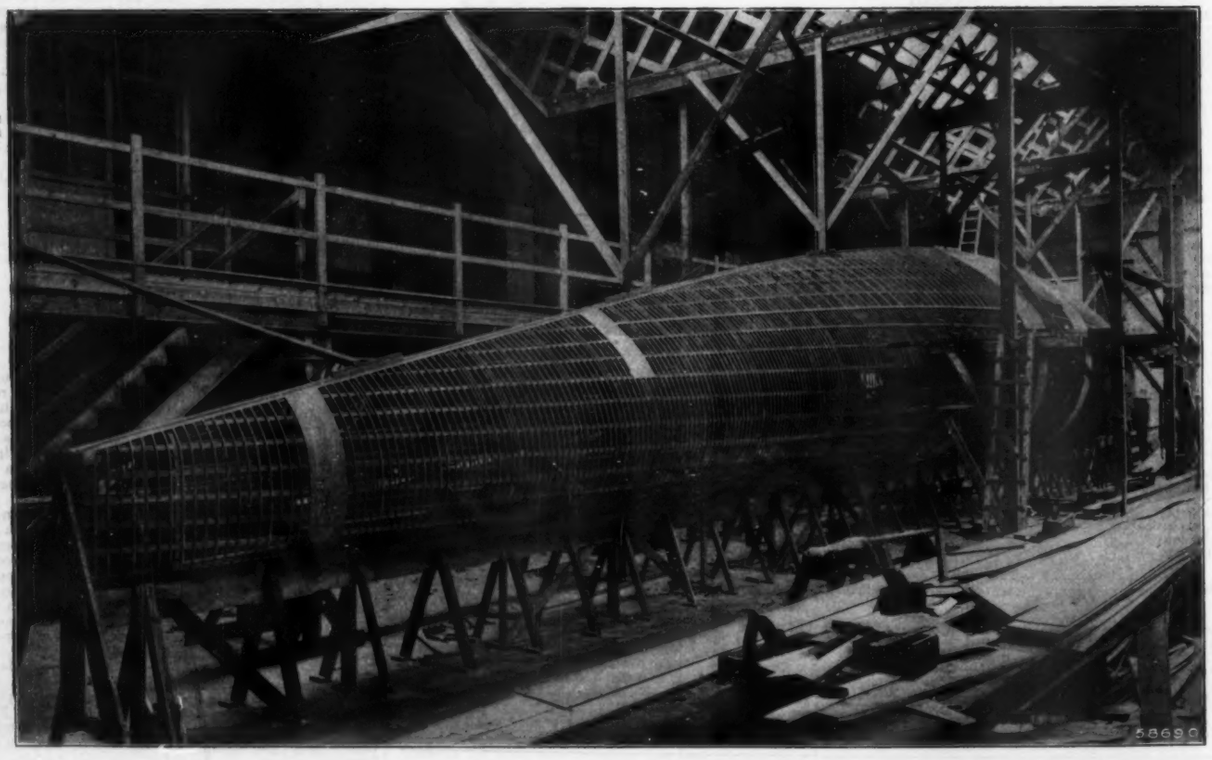


FIG. 14. TYPE N4. HULL IN FRAME.

Following are a few comparative weights relating to the F, P and N types already described.

Since the F 5 and P 5 boats are of similar dimensions, and designed to lift the same weight, 12,000 lb., the lightest hull adds greatly to the operational value of the boat.

The rate of production of the various types of boats built in one shipyard show the following figures :—

Ten men built an N 4 hull in from 12 to 13 weeks, three of these being experienced boat-builders, five joiners, and two apprentices. The construction of an F boat required two skilled boat-builders, and the highly-skilled labour is 50 per cent., and 40 per cent. semi-skilled, with an increase of time of under 10 per cent. Boats of the F type took 4,830 man-hours for 560 sq. ft.; while on the N 4 there were 7,500 man-hours for 1,320 sq. ft., equal to 8·6 man-hours per square foot on the F and 5·6 for the N 4. The N 4 shows a

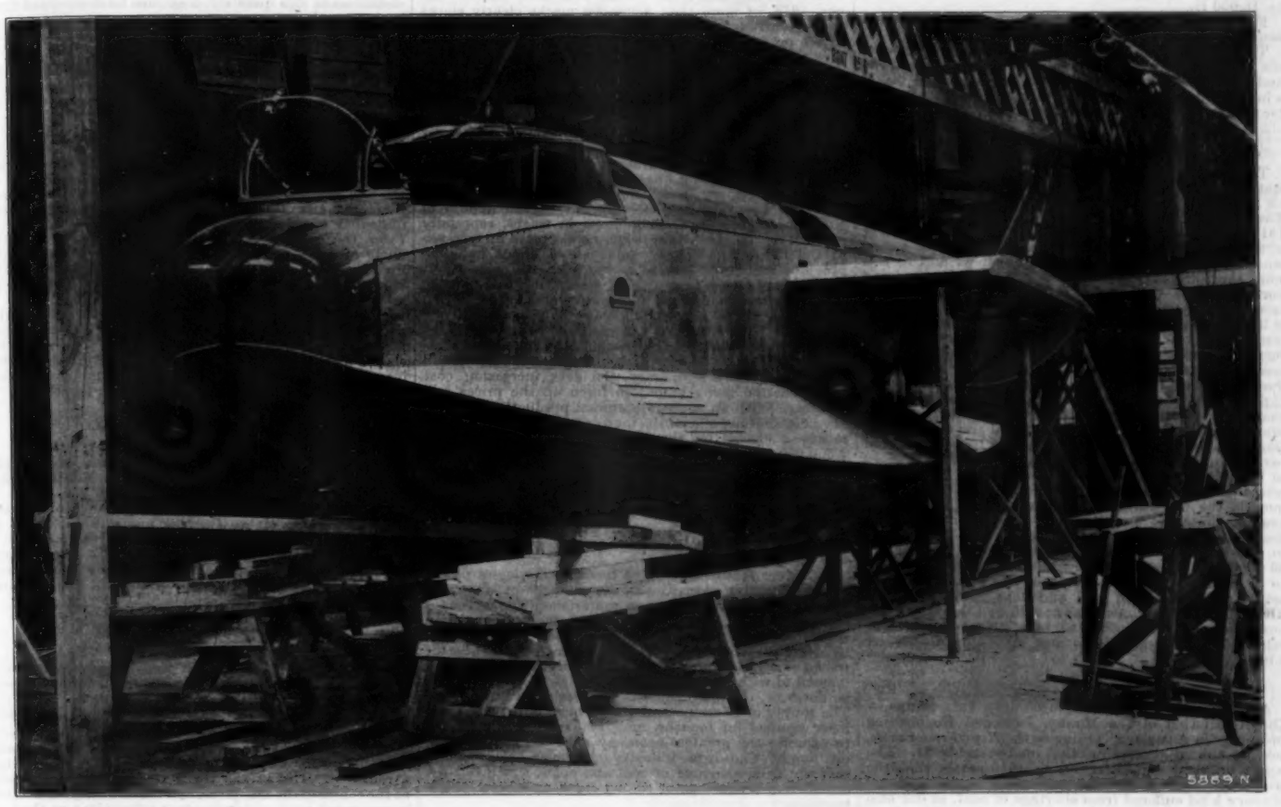


FIG. 15. TYPE F 3. HULL NEARING COMPLETION.

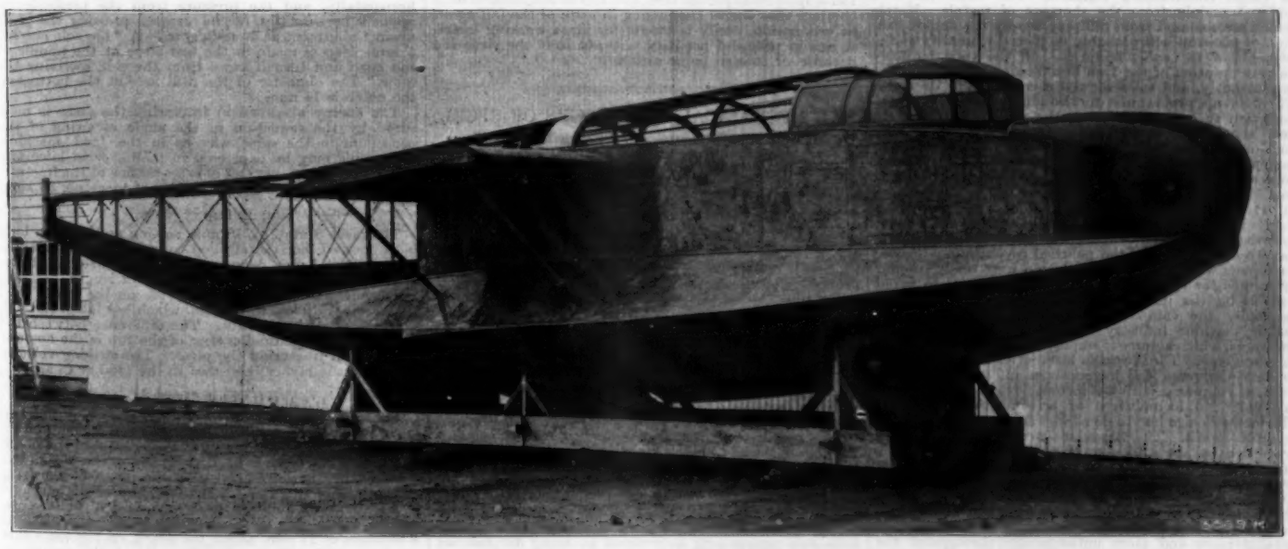


FIG. 16. TYPE F. HULL READY FOR MOUNTING WINGS AND ENGINES.

The total weight of each of two F 5 boats built by different firms, from official plans, only differed by 4 lb., the average weight being 2,174 lb., including wing roots, cloche, seats, and tank seats; deducting 333 lb. for cloche, seats, &c., leaves a weight for bare hull of 1,841 lb. The P 5 hull only weighs 1,321 lb. with the same fittings, therefore the F 5 is nearly 40 per cent. heavier than the P 5.

rest as in the previous case—seven men in all—and they took from 11 to 11¼ weeks.

As the N 4 has 1,320 sq. ft. of planking on the main hull, compared with 560 sq. ft. in P 5, which is the same size as F 3, the saving on man-power hours is very much in favour of the larger boat and its particular construction. The increase in area between 1,320 sq. ft. and 560 sq. ft. is roughly 236 per cent., while the increase of saving in man-hours per square foot of surface of over 34 per cent. when compared with the F type.

The F boats are propelled by two Eagle Rolls-Royce engines, each developing 345 h.p., giving a speed of 100 m.p.h. The wings have no appreciable dihedral angle or stagger, and are almost square at the wing tips. The span of the top wing is 102 ft. Small wing floats are fitted underneath, and almost at the extremities

of the lower planes. The rudder is ear-shaped, the bottom of which is in line with the bottom of the boat.

The N boat has an overall length of 70 ft., carries a crew of nine, and 1,000 gallons of fuel. Her wings are of the variable camber device, and the span is 142 ft. She is fitted with four Rolls-Condor engines, each giving 640 h.p. under dual control, and has a sea-level speed of 110 m.p.h., while her ceiling will be from 17,000 ft. to 18,000 ft.

Fig. 13, page 684, illustrates in outline the profile and sections of various types of flying boats.

The table on page 683 shows the relationship between the performances of some of the boats, and on pages 684 and 685 are shown views of a hull in frame (Fig. 14), of a hull nearing completion (Fig. 15), and of a hull ready for mounting the wings and engines (Fig. 16).

THE GERMAN COAL TAX.—According to recent statistics the German coal tax, which came into operation on August 1, 1917, yielded an aggregate revenue to the Exchequer of 412,898,000 marks for the period August 1, 1917, to April 1, 1918. For the period April to December of the financial year 1918, the revenue from this source amounted to 576,844,000 marks, and, if we add to this sum, the estimated yield of the tax for the remaining portion of the financial year (that in the first three months of the current year) a total of 750,000,000 marks is likely to be the result. The revenue expected on the introduction of the tax was 500,000,000 marks. The surplus, it is hardly necessary to point out, is not due to increased production, which has materially diminished during the last few months, but arises solely from the higher prices charged for coal and coke, the tax being chargeable, at the rate of 20 per cent., on the selling price. In peace times the prices of coal and coke ranged from 12 marks to 18 marks, but at the time of the coal tax coming into operation the prices had already risen to 17 marks to 25 marks, while on January 1, 1919, the prices had reached 46 marks to 60 marks, and consequently the tax during the first quarter of the present year amounted to 9 marks to 12 marks per ton. Had the coal syndicate been able to carry out their intention to still further increase the prices from April 1, to 66 marks to 90 marks, the coal tax would have amounted to 13 marks to 18 marks per ton, this figure being the actual selling price of coal and coke before the war. Although the Government has not allowed this latest proposed increased in prices to take place, the present exhorbitant demands of the men may soon necessitate a further rise.

AUSTRIAN MINING AND ENGINEERING INDUSTRIES.—The Association of the Mining, Iron and Engineering Industries in Austria, according to the *Neue Freie Presse*, held an annual general meeting on December 21. The report on their condition during 1918 states that the armament industry and the production of war material of every kind suffered from shortage of coal, as did also the special steel and tool steel industries. The first-named branches were nevertheless kept busy until the conclusion of hostilities made necessary the adaptation of the factories to peace purposes. The production of munitions was stopped in good time, and the production of peace commodities resumed. The cable factories suffered mainly from the shortage of metals. Metals which are released from military use by the demobilisation of material will probably be placed primarily at the disposal of the cable factories. In the tube industry the intervention of the Iron Commission made itself felt unpleasantly, and sales showed a considerable decrease. There is no programme for building and bridge construction to carry out during the period of transition, and accordingly these branches cannot expect any considerable employment in the near future. In the manufacture of iron chains there is a large stock of contracts remaining over. The engineering industry was less fully employed in the year under review than in the previous year. Numerous inquiries showed a lively interest in machines for the petroleum, sugar, brewing, distilling and chemical industries, but no orders have been given since the political revolution. Private customers who before the revolution were ready to offer premiums for rapid delivery are now anxious to avoid purchasing the machines they have ordered. This is especially the case with Hungarian customers. The textile machine industry has a considerable stock of contracts, which assures it employment for a considerable time to come. The Austrian locomotive industry is said to have delivered 463 locomotives and 130 tenders in 1918, as compared with 398 locomotives and 226 tenders in 1917. No locomotives or tenders were exported. The factories also had to do a large amount of locomotive repairing work. The Austrian carriage factories were prevented by the difficulty of obtaining materials and fuel from carrying out their original programme of production, and it is claimed that they delivered about 9,000 coaches and trucks during 1918, as compared with about 14,000 in the previous year. The report points out that the general situation of the industries in question became more and more unfavourable throughout the year, and had been adversely affected of late by the establishment of several independent political and economic areas within the territory of the late Dual Monarchy. None of the new States had a sufficient supply of both coal and iron to secure its economic independence of the others, and the interest of all nationalities alike required that the present policy of economic separatism should be discontinued as early as possible. In coal mining conditions had become catastrophic since the political revolution, and it cannot yet be foreseen whether or when the situation will improve.

THE POSITION OF THE GERMAN MINING AND IRON INDUSTRIES.

One of the leading German mining concerns has recently expressed its views concerning the present heavy working losses of the German mining and iron industry. The fact that one of the important iron works had incurred a loss during November and December, 1918, of more than 5,000,000 marks clearly shows the seriousness of the situation. Among the difficulties of the present time the increase in wages must take the first place, this increase having continued on an ever-growing scale since the time of the revolution. Even a slight increase in wages has a decisive influence upon the financial results of an industrial undertaking; a rise of 12 marks per shift, for instance, in the case of a medium sized concern, with some 180,000 shifts per month means an additional expenditure of more than 2,000,000 marks per annum. After the revolution, however, it was not a question of 1 mark but several marks increase per shift. Further, the shorter working day introduced by the Government in the middle of November means a great increase in wages, especially in the iron industry where it has necessitated an increase in the number of hands employed of about half the previous number. This, of course, means a corresponding increase in the wages total, amounting to 1,000,000 marks per month for a medium-sized works. In addition the rise in wages materially affects the prices of all raw materials. Thus the price of coal was raised 14 marks per ton from January 1, a rise which the Socialists themselves attributed to the higher wages. This rise will probably be only temporary, the ever increasing cost of production being bound to force up the prices still further. With an aggregate annual production of some 150,000,000 tons of coal the increase of 14 marks per ton means a charge on the German community of some 2,500,000,000 marks per annum. The effect upon the railways is also very serious. The rise in the price of coal adds another 150,000,000 marks to the deficit of 1,000,000,000 marks for the Prussian State railways, and thus the railways will have again to increase their fares and charges by about 50 per cent. This means that railway freights will soon be twice as high as in pre-war times.

Another factor tending to increase the losses of the iron and mining industries is the shortage of labour, in addition to a shortage of raw materials. The increased requirements of labour owing to the shorter hours and the repatriation of prisoners of war can only be filled by degrees. Many works, therefore, have to be idle for weeks at a time, and others can only work with one shift instead of with two or three. Shortage of raw materials is, however, the main cause of the closing of iron works. The supply of Lorraine and Luxemburg Minette ore has been stopped for months, and it has become necessary to exercise the greatest economy with the small stocks on hand. The iron industry, however, also suffers severely from shortage of coal and coke, which in turn arises from a shortage of rolling stock and from labour troubles.

The financial result, of course, depends to a great extent upon production; if this diminishes, parts of the works and plant cannot be fully utilised and as a result the cost of production increases. Moreover, in accordance with the new regulations, the works have to find full employment for the men, and this in conjunction with the fact that wages keep rising in spite of the falling off in production, easily accounts for large working losses. A rise in prices of products will not save the situation because of foreign competition.

THE MECHANICAL PROPERTIES OF STEEL.

*The Mechanical Properties of Steel, with Some Consideration of the Question of Brittleness.**

By W. H. HATFIELD, D.Met., of the Brown-Firth Research Laboratory, Sheffield, Associate Member.

(*Concluded from page* 636.)

APPENDIX I.

The details of the various mechanical tests employed in this investigation are stated in the following paragraphs:—

For illustrations of *d*, *e*, *f*, *g*, *h* and *i*, *see* Fig. 22.

(*a*) TENSILE TEST.

Tensile tests are carried out in our 50,000 kgm. "Olsen" testing machine. This machine is of the multiple-lever type, and is fitted with gear for automatically adjusting the jockey-weight forward or backwards so as to keep the lever in balance. The standard form of test-piece is 2 in. parallel, 0·564 in. diameter, and overall length 7 in. The pull is applied through heads in the ends of the test-piece, 1¼ in. diameter. These are held in screw adapters which connect through the shackles of the machine by spherical seated nuts. The standard rate of pulling adopted is 0·31 in. per minute. The yield-point of the material is taken as the stress which gives a permanent set of the test-piece of $\frac{1}{1000}$-in. For ordinary tests this extension is determined by using dividers set to the gauge length. For special tests, including determinations of the elastic limit of the material, an extensometer of the "Ewing" type is fitted to the test-piece. In this instrument a small glass scale is given a movement equal to five times the extension of the test-piece, across the objective of a microscope. By means of another scale in the eyepiece of the microscope the extension of the test-piece is easily measured in units of $\frac{1}{1000}$-in. For determination of the elastic limit, gradually increasing loads are applied to the piece, and the extension for each load is observed. From the results, a graph is plotted showing the relation between load and elongation. The elastic limit of the material is taken as the limit of proportionality, which is indicated by the upper end of the straight line portion of the graph which is obtained. The yield-point, according to the previous definition of this quantity, may also be determined from such a graph.

(*b*) TORSION TEST.

The torsion test consists of twisting to destruction of a suitably prepared test-piece, and observing the torque or twisting moment required to do this, and the amount of deformation produced in the test-piece. The dimensions adopted for the tests are: Overall length, 5 in.; parallel portion ⅝ in. diameter, 2 in. long, with heads 1 in. square at the ends. The ends of the parallel portion are turned to ¼-in. radius. The tests are carried out in a 10,000 in.-lb. "Avery" torsion machine. In the first portion of the test the angle of twist is increased by increments of half a degree, and the twisting moment indicated by the machine for each angle is observed. From the readings a graph is prepared, connecting the angle of twist and the twisting moment, and from the limit of proportionality indicated by this graph the value of the twisting moment at elastic limit of the material is obtained. Observations are also made of the maximum twisting moment endured by the material and of the total angle of twist up to fracture of the test-piece. The values of twisting moment obtained for elastic limit and for the maximum stress are converted into terms of shear stress by application of the usual formula for shear stress in twisted shafts, namely,

$$\text{Twisting moment} = \frac{\pi}{16} D^3 f,$$

where f, denotes the intensity of the shear stress at the skin of the material. This formula only strictly applies to conditions within the elastic range. The value of f, calculated from this formula by substituting the maximum value of the twisting moment is referred to as the "apparent maximum stress" on the material.

It is recognised that this formula does not indicate the real maximum shear stress which the material can stand, and that a more likely value for this quantity is obtained by using the formula:

$$\text{Twisting moment} = \frac{\pi}{12} D^3 f_s,$$

the value of f_s obtained from this latter calculation is referred to as the "probable actual maximum shear stress."

(*c*) BEND TEST.

A rectangular piece ½-in. by ½-in. section, and about 8 in. long, is supported with the broadside horizontally on rollers 3 in. diameter at 5½ in. span. A tool having a radius of ½ in. at the tip is pressed down vertically at the centre of the test-piece, and the downward deflection is continued until either fracture takes place or the legs of the piece have become parallel. The angle of bend at which the fracture takes place, if it does so, is noted.

(*d*) CHARPY TEST.

The test-piece 10 mm. square, 60 mm. long, is supported horizontally, and the pressure from the pendulum is applied horizontally at its centre, pressing the piece against abutment at 40 mm. span. A "keyhole notch" 5 mm. deep is made in the test-piece at the middle of the span and turned away from the side receiving the blow. The diameter of the drill hole at the bottom of the notch is 1½ mm.

The energy absorbed in fracturing the piece is measured by the reduction in the angle of swing of the pendulum in the same way as in the Izod machine. The result may be expressed in ft.-lb., or in kilogrammetres, or in kgm. per cm² of cross-section at the fracture. Weight of tup, 22·5 kg. Capacity of machine, 30 kgm.

(*e*) FRÉMONT TEST.

The piece 8 mm. by 10 mm. section and 30 mm. long is supported horizontally on supports 21 mm. span. The notch is 1 mm. deep and 1 mm. wide, square shape, made on the broadside at the centre of length.

The piece is fixed with the notch on the under side, and receives a blow from a tup which has fallen through a height of several metres. The difference between the initial and the residual energy of the tup is the amount absorbed in fracturing the piece. The striking velocity in this test is higher than that in the Izod or Charpy.

(*f*) IZOD TEST.

The test-piece 10 mm. square in section is notched transversely by a V cutter, to a depth of 2 mm. and an angle of 45 deg. The radius at the bottom of the notch is ¼ mm. The piece is fixed vertically in the vice of the machine by the lower end with the notch at the level of the face of the vice. The pendulum of the machine is released, when it swings freely, and a knife edge carried in the tup of the machine strikes the place at a distance of 22 mm. above the notch, on the same side as the notch. The angle of swing of the pendulum beyond the vertical after breaking the test-piece is indicated by a pointer which should have been previously set to zero. From amount by which the angle falls short of the angle to which the pendulum would have swung if there had been no test-piece, the amount of energy absorbed in breaking the test-piece is known, and is read by the pointer in ft.-lb.

Three tests are usually done on one piece, the notches being placed on different sides of the piece. The height of fall of the centre of mass of the pendulum is 2½ ft., and the capacity of the machine 150 ft.-lb., or 120 ft.-lb.,

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* Paper read before the Institution of Mechanical Engineers, on Friday, May 2, 1919.

the distance from the pivot to the striking edge being 4 ft. The striking velocity (when using the full capacity of the machine) is 13·6 ft.-sec.

(g) ARNOLD ALTERNATING TEST.

The piece ⅝ in. diameter and 5 ft. 6 in. long is rigidly clamped in a vertical position in the vice of the machine. A collar fits loosely over the top of the piece, at a height of 3 in. above the face of the dies, and is given a reciprocating motion, causing it to bend the piece alternately backwards and forwards through a distance of ⅝ in. on either side of the vertical. The standard speed adopted is 650 alternations per minute. The number of alternations to fracture is recorded.

(h) STANTON TEST.

This is an alternating shock test. The test-piece is turned to ½ in. diameter and 6½ in. long. It is supported by supports 4½ in. span. The test-piece has a groove turned round the centre of the span 0·05 in. deep and 0·05 in. wide. The corners of the groove are practically square, the actual radius approximating to 0·001 in. This is fixed in the machine where it receives blows from a hammer whose weight is 4·7 lb., and of which the height of fall is adjustable. In the present tests the height of fall is kept at 2 in. After each blow the machine rotates the test-piece through 180 deg. The frequency of the blows is kept fairly constant at 96 per minute. The test is allowed to proceed until the piece fractures at the groove, and the number of blows withstood before fracture is recorded by a counter on the machine. The machine itself has a fairly heavy bed-plate, and is allowed to rest on a concrete floor. This gives a fairly firm foundation to withstand the shock.

A complete description of this machine, which is called the "Stanton Repeated-Blow Impact Machine," and is made by the Cambridge Scientific Instrument Company, may be found in this company's catalogues, or in the Journal of the Iron and Steel Institute, Carnegie number for 1914.

(i) SANKEY TEST.

This is carried out in a machine made by Messrs. Cassell and Co., Limited. The test-piece is ⅜ in. diameter and 4 in. long. It is clamped at one end in a grip carried at one end of a stiff cantilever spring. At the other end of the piece a long handle is fixed, leaving a free length of test-piece of 1¾ in. This is bent backwards and forwards through a standard angle which is about 45½ in. on each side of the straight, until the piece breaks. The slight movement of the spring actuates a mechanism which records the value of bending moment put on to the piece at each reversal. From the autographic diagram, the amount of energy expended in fracture can be determined.

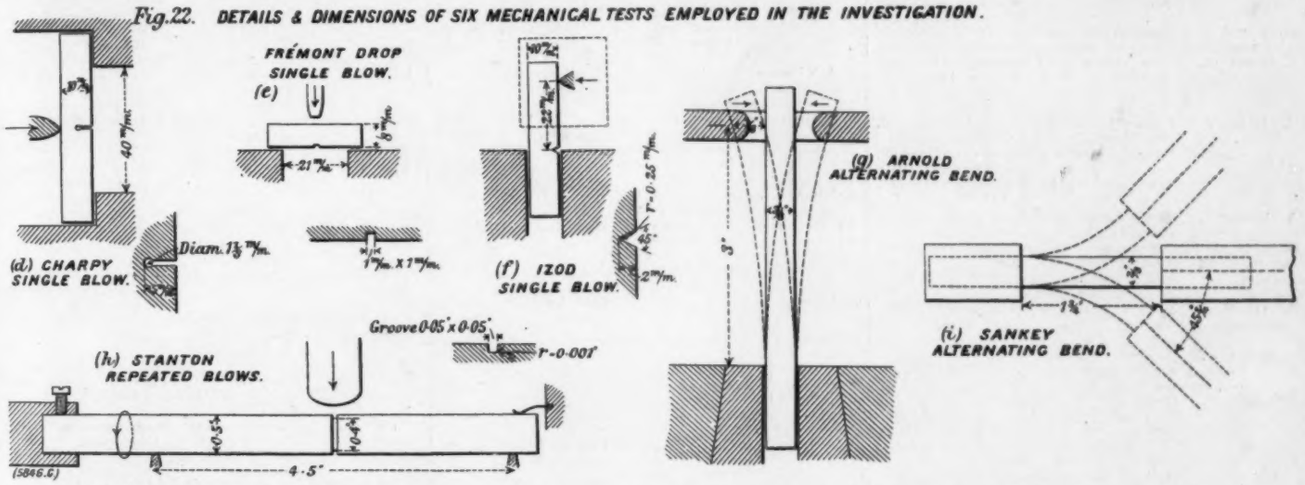
(j) BRINELL TEST.

This consists of pressing a hard steel ball 10 mm. diameter into a flat surface of the material to be tested, with a standard pressure, and measuring the diameter of the permanent impression made. The pressure is obtained by oil acting on a small piston, and operated by a hand pump. The standard test is made with pressure of 3,000 kg. kept steady for 30 seconds. With small samples, the steady pressure used may be made 1,500 kg. or 500 kg. In each case the hardness value is given as the pressure per square millimetre of the concave surface of the impression. The conversions from millimetres diameter to hardness number are ready worked out in the form of a table.

(k) SCLEROSCOPE HARDNESS TESTS.

These are by means of the "Shore Scleroscope." The instrument consists of a glass tube about 10 in. long in which slides a small steel hammer, having a diamond tip at the underside. The material to be tested has one surface ground and polished to a finish corresponding to about F. emery cloth. The tube is placed vertically over the surface, in contact with it, the piece being rigidly held. The hammer is released from the top of the tube, and a scale reading taken corresponding to the height of the rebound, and this represents the hardness of the material in degree "Shore." The instrument is checked for accuracy in reading by obtaining the values given by specially prepared blocks of standard hardness, supplied by the Shore Instrument Company.

Fig. 22. DETAILS & DIMENSIONS OF SIX MECHANICAL TESTS EMPLOYED IN THE INVESTIGATION.



APPENDIX II.

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Hopkinson ...	"A High-Speed Fatigue Tester."	Proc. Roy. Soc., vol. 86, p. 131.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—This Society has sent out particulars of trials of agricultural tractors and ploughs, to be held in the autumn of 1920. Full information can be had from the Secretary, 16, Bedford-squatre, W.C. 1.

THE INSTITUTION OF MECHANICAL ENGINEERS.—The Council believe that an opportunity of visiting the devastated districts of Northern France would be greatly appreciated by members, and have accordingly directed inquiries to be made with a view to arranging a visit, with headquarters at Lille, during the last week in July returning before the August Bank Holiday. It appears almost certain that such a visit must be limited to 100 members (without ladies), and that it would be necessary to divide into two parties, the one at first visiting Amiens and then proceeding to Lille, and the other visiting Lille and then going to Amiens. Travelling between the French coast and Lille and Amiens would be by rail, and expeditions from these two centres to engineering works and battle areas would be by motors. It is hoped that a visit to Ypres (Belgium) may be also possible. At present the estimated cost, including hotels, food, and transport for eight days, is 60*l.* for each member attending. In case a larger number than 100 members wish to join the party, it may be necessary to ballot. Members who propose to take part in the visit, have to complete and return a reply form before May 26, as arrangements are necessarily difficult for such a visit, and entail considerable preparation. Further particulars will be issued to those members who intimate their wish to join the party if formed.